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8 SURFACE WATER, SEDIMENT, AND BENTHIC MACROINVERTEBRATE INVESTIGATION

8.1 INTRODUCTION AND OBJECTIVES

Surface water, sediment, and benthic macroinvertebrate samples were collected from all the significant creeks at JPG from 7-11 October 2002. Creeks were sampled near the entrance and exit points to the installation, and near the midpoint to be closer to the source of possible contamination. Upstream locations were used as a reference. The objective of the sampling was to collect data needed to determine if munitions constituents were impacting the aquatic ecological health of JPG or migrating through the surface water pathway.

8.2 TECHNICAL APPROACH

8.2.1 Sampling Protocol

Prior to field activities and sample collection, a QAPP (USACHPPM, 2002) was developed for JPG, which outlined the surface water, sediment, and macroinvertebrate sampling strategy and rationale. The strategy involved the collection of physical, chemical, and biological data in order to assess the overall ecological health of JPG surface waters. Sampling locations were selected based on U.S. Geological Survey topographic maps, observations of creeks during the site visit 6-10 May 2002, and knowledge of the environmental setting and munitions usage at JPG. The sampling locations are shown in Figure 8-1. A detailed description of the sampling locations is in Appendix E. The drainage basins identified for sampling are briefly described in each watershed section.

8.2.2 Number and Type of Samples, Target Analytes, Analytical Methods, and Detection Limits

At each sampling location, one surface water, one sediment, and three benthic macroinvertebrate samples were collected. Both filtered and unfiltered water samples were collected for total and dissolved metals analysis, respectively. Two duplicate and two split samples were collected for QA/QC purposes. Sample 19 was a duplicate for sample 16, sample 20 was a duplicate for sample 04, sample 21 was a split for sample 05, and sample 22 was a split for sample 06. Table 8-1 shows the laboratory methods and detection limits for the surface water samples. Table 8-2 shows the laboratory methods and detection limits for the sediment samples. The analyte list was based on the munitions-related constituents.

FIGURE 8-1. SAMPLING LOCATIONS, SURFACE WATER, AND SEDIMENT

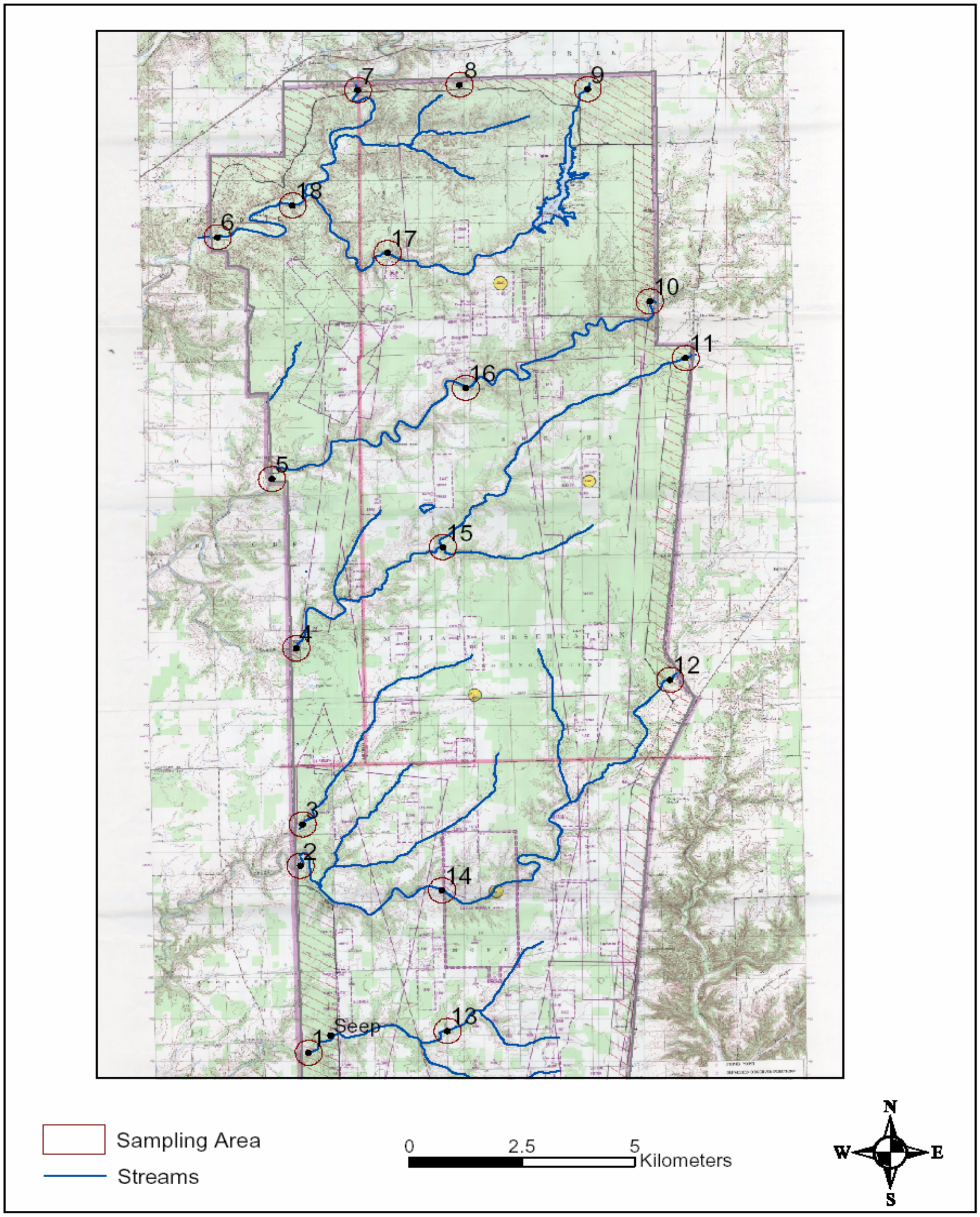


TABLE 8-1 PARAMETER LIST, ANALYTICAL METHOD, REPORTING LIMIT, AND PERFORMING LABORATORY FOR CHEMICAL DATA IN SURFACE WATER

Parameter	Analytical Method	Reporting Limit (µg/l)	Laboratory Performing Analyses
EXPLOSIVES AND DEGRADATES			
HMX	USEPA 8095M / CAD 13.2	3	U.S. Army Center for Health Promotion and Preventive Medicine, Aberdeen Proving Ground, Maryland or Contractor
RDX	USEPA 8095M / CAD 13.2	0.3	
2,4,6-TNT	USEPA 8095M / CAD 13.2	0.03	
1,3,5-TNB	USEPA 8095M / CAD 13.2	0.03	
1,3-DNB	USEPA 8095M / CAD 13.2	0.09	
TETRYL	USEPA 8095M / CAD 13.2	0.5	
NB	USEPA 8095M / CAD 13.2	0.03	
2A-4,6-DNT	USEPA 8095M / CAD 13.2	0.1	
4A-2,6-DNT	USEPA 8095M / CAD 13.2	0.1	
2,6-DNT	USEPA 8095M / CAD 13.2	0.01	
2,4-DNT	USEPA 8095M / CAD 13.2	0.02	
2-NT	USEPA 8095M / CAD 13.2	0.09	
3-NT	USEPA 8095M / CAD 13.2	0.09	
4-NT	USEPA 8095M / CAD 13.2	0.09	
Nitroglycerin	USEPA 8095M / CAD 13.2	0.09	
White phosphorous	CHPPM /CAD MUS 5	0.005	
Perchlorate	USEPA 314	1	DATACHEM
METALS			
Antimony	USEPA 1638-ICP/MS	0.00891	Battelle, 760 6th Street, Richland, Washington 99352 Clean Laboratory – Trace Metals Method
Arsenic	USEPA 1638-ICP/MS	0.0436	
Barium	USEPA 1638-ICP/MS	0.00564	
Cadmium	USEPA 1638-ICP/MS	0.015	
Calcium	USEPA 1638-ICP/MS	1.75	
Chromium	USEPA 1638-ICP/MS	0.042	
Copper	USEPA 1638-ICP/MS	0.0135	
Lead	USEPA 1638-ICP/MS	0.0049	
Magnesium	USEPA 1638-ICP/MS	0.05	
Manganese	USEPA 1638-ICP/MS	0.01	
Mercury	USEPA 1631-CVAF	0.0002	
Molybdenum	USEPA 1638-ICP/MS	0.00826	
Nickel	USEPA 1638-ICP/MS	0.0323	
Silver	USEPA 1638-ICP/MS	0.00429	
Uranium	USEPA 1638-ICP/MS	0.01	
Vanadium	USEPA 1638-ICP/MS	0.0173	
Zinc	USEPA 1638-ICP/MS	0.0352	

NOTES: ICP/MS = inductively coupled plasma/mass spectrometry.
CVAF= cold vapor atomic furnace.

TABLE 8-2 PARAMETER LIST, ANALYTICAL METHOD, REPORTING LIMIT, AND PERFORMING LABORATORY FOR CHEMICAL DATA IN SEDIMENT

Parameter	Analytical Method	Reporting Limit (µg/g)	Laboratory Performing Analyses
EXPLOSIVES AND DEGRADATES			
HMX	USEPA 8095M / CAD 55.2	0.05	U.S. Army Center for Health Promotion and Preventive Medicine, Aberdeen Proving Ground, Maryland
RDX	USEPA 8095M / CAD 55.2	0.01	
2,4,6-TNT	USEPA 8095M / CAD 55.2	0.01	
1,3,5-TNB	USEPA 8095M / CAD 55.2	0.02	
1,3-DNB	USEPA 8095M / CAD 55.2	0.02	
TETRYL	USEPA 8095M / CAD 55.2	0.02	
NB	USEPA 8095M / CAD 55.2	0.02	
2A-4,6-DNT	USEPA 8095M / CAD 55.2	0.02	
4A-2,6-DNT	USEPA 8095M / CAD 55.2	0.05	
2,6-DNT	USEPA 8095M / CAD 55.2	0.02	
2,4-DNT	USEPA 8095M / CAD 55.2	0.02	
2-NT	USEPA 8095M / CAD 55.2	0.02	
3-NT	USEPA 8095M / CAD 55.2	0.02	
4-NT	USEPA 8095M / CAD 55.2	0.02	
Nitroglycerin	USEPA 8095M / CAD 55.2	0.05	
White phosphorous	CHPPM / CAD MUS 5	0.00088	
Perchlorate	USEPA 300	0.04	DATACHEM
METALS			
Antimony	USEPA 200.8 / 6020 *	0.00891	Battelle Memorial Institute, 790 6th Street, Richland, Washington, 99352
Arsenic	USEPA 200.8 / 6020 *	0.0436	
Barium	USEPA 200.8 / 6020 *	0.170	
Cadmium	USEPA 200.8 / 6020 *	0.022	
Chromium	USEPA 200.8 / 6020 *	0.149	
Copper	USEPA 200.8 / 6020 *	0.175	
Lead	USEPA 200.8 / 6020 *	0.00049	
Manganese	USEPA 200.8 / 6020 *	0.010	
Mercury	USEPA 245.5 *	0.01	
Molybdenum	USEPA 200.8 / 6020 *	0.00826	
Nickel	USEPA 200.8 / 6020 *	0.220	
Silver	USEPA 200.8 / 6020 *	0.031	
Uranium	USEPA 200.8 / 6020 *	0.05	
Vanadium	USEPA 200.8 / 6020 *	0.126	
Zinc	USEPA 200.8 / 6020 *	0.706	
MISCELLANEOUS			
TOM	MSA 29-352 **	0.01 %	USACHPPM

NOTES:
CHPPM CAD = U. S. Army Center for Health Promotion and Preventive Medicine, Directorate of Laboratory Sciences, Chromatographic Analysis Division.
TOM= total organic matter.
* - These methods use clean techniques for digestion and analysis as described in USEPA, 1996b, Sampling Ambient Water for Trace Metals at USEPA Water Quality Criteria Levels, Office of Water, Engineering and Analysis Division, Washington, D.C.
** - Methods of Soil Analysis (MSA) 29-352 is the Walkley-Black method.

8.2.3 Water Quality Criteria, Sediment Benchmarks, and Biological Indices

Table 8-3 presents the Federal Water Quality Criteria (WQC), Indiana State Water Quality Standards (WQSs), and Sediment Quality Benchmarks (SQBs) for the protection of freshwater aquatic life. This table was used for qualitative comparison to the surface water and sediment chemical results to determine if there were any of the munitions-related constituents at a concentration that could be considered a risk to the aquatic ecosystem. Additionally, benthic macroinvertebrate data were used to calculate indices to compare reference locations and downstream locations to determine if there were any adverse effects on the ecological health of the aquatic biota. The details about water quality criteria, benchmarks, and biological indices can be found in Section 4.1.7 of the QAPP (USACHPPM, 2002).

8.3 SUMMARY OF FIELD ACTIVITIES

The sampling was originally scheduled for 16-25 September 2002. However, an extended drought left the creeks with very little flow and no flow at a majority of the sampling locations. The creeks were a series of stagnant pools. It was decided to delay sampling until there was flow. Table 8-4 shows the stream flow in Harberts Creek, a creek south of the firing line at JPG that has a gauging station about 3 miles downstream of the installation. There was 6-7 inches of rain on 27 September and the stream flow had returned to base flow within 3 days. The stream flow was stable for over a week at the time of sampling (7-11 October 2002) and stayed stable throughout the sampling period.

8.3.1 Unexploded Ordnance Safety Support

Prior to field activities, contracted unexploded ordnance (UXO) personnel briefed all sampling personnel on safety procedures while working in areas that may contain UXO. Additionally, contracted UXO personnel escorted the stream sampling team to all sampling locations in and around the impact areas. No samples were collected at impact area locations until a visual sweep of the sampling area was made and the location had been cleared for sampling. All field activities and sampling procedures were performed in accordance with the Site-Specific Safety and Health Plan developed in the QAPP (USACHPPM, 2002).

8.3.2 Surface Water Sampling

At each sampling location, surface water samples were collected by pumping the sample into the sample container using a continuous flow pump using Teflon tubing. The water samples were taken half way across the width of the stream and at a depth half way between the water surface and the streambed. Stagnant or ponded water was not collected. Both total (unfiltered) and dissolved (filtered) samples were collected for trace metals analysis. A 0.45-micron precleaned filter was added to the sample tubing line for dissolved metals sample collection. Water samples for trace metals analysis were collected per USEPA Method 1669 - *Sampling Ambient Water for Trace Metals at USEPA Water Quality Criteria Levels*. The “clean-hands - dirty-hands” technique was used to collect the trace metals samples, as described in the QAPP. All sampling equipment and containers were precleaned by either Battelle Laboratories (clean metals) or USACHPPM Laboratories (explosives and miscellaneous parameters) as outlined in the QAPP.

TABLE 8-3 FEDERAL AND STATE OF INDIANA AMBIENT WATER QUALITY CRITERIA FOR PROTECTION OF AQUATIC LIFE IN FRESH WATER AND SEDIMENT QUALITY BENCHMARKS

PARAMETER	FEDERAL AMBIENT WATER QUALITY CRITERIA (µg/L)		INDIANA AMBIENT WATER QUALITY CRITERIA (µg/L) [12]		SEDIMENT QUALITY BENCHMARK (µg/g)
	CMC	CCC	ACUTE	CHRONIC	
EXPLOSIVES AND DEGRADATES					
HMX	NA	330 [6,8]	NA No numeric criteria have been established for these compounds. However, the concentration of these compounds will not result in chronic or acute toxicity to aquatic life, or impairment of the designated uses.		0.330 [1]
RDX	4000 [6,7]	190 [6,8]			0.190 [1]
2,4,6-TNT	560 [6,7]	<40 [6,7]			0.13 [1]
1,3,5-TNB	30 [6,8]	14 [6,8]			0.02 [1]
1,3-DNB	110 [6,8]	30 [6,8]			0.04 [1]
TETRYL	NA				NA
NB	27,000 [6,7,9]				27.0 [1]
2A-4,6-DNT	NA	NA			NA
4A-2,6-DNT	NA	NA			NA
2,6-DNT	18,500 [6,7]	NA			18.5 [1]
2,4-DNT	330 [9]	230 [9]			0.230 [1]
2-NT	NA	NA			NA
3-NT	NA	NA			NA
4-NT	NA	NA			NA
Nitroglycerin	1700 [6,7]	200 [6,7]			NA
White Phosphorous	0.5 [6]	0.1 [6]			0.26 [6]
Perchlorate	5,000 [6]	600 [6]			NA
METALS					
Antimony	180 [6]	30 [6]	NA	NA	NA
Arsenic	340 [11]	150 [11]	360	190	5.9 [2]
Barium	1000 [13]		1000		500 [3]
Cadmium	4.3 [5,11]	2.2 [5,11]	4.0 [5]	1.1 [5]	0.596 [2]
Calcium	NA				
Chromium	570 [11]	74 [11]	1737	207	26 [3]
Copper	13 [5,11]	9 [5,11]	18 [5]	9 [5]	16 [3]
Lead	65 [5,11]	2.5 [5,11]	82 [5]	3 [5]	31 [3]
Magnesium	NA				
Manganese	50 [13]		NA	NA	460 [3]
Mercury	2.4 [11]	0.012 [11]	2.4	0.012	0.174 [2]
Molybdenum	16,000 [6]	370 [6]	NA	NA	NA
Nickel	470 [5,11]	52 [5,11]	1418 [5]	158 [5]	21 [10]
Silver	3.4 [5,11]	NA	2.0 [5]	NA	1 [4]
Uranium	46 [6]	2.6 [6]	NA	NA	NA
Vanadium	280 [6]	20 [6]	NA	NA	NA
Zinc	120 [5,11]	120 [5,11]	117 [5]	106 [5]	124 [4]

Notes for Table 8-3 – Federal and State of Indiana Ambient Water Quality Criteria for the Protection of Aquatic Life in Freshwater, and Sediment Quality Benchmarks, Jefferson Proving Ground, Indiana Criteria are elements of water quality standards, expressed as concentrations, levels, or narrative statements representing a quality of water that supports a particular use. When criteria are met, water quality will generally protect the designated use.

CMC – criteria maximum concentration. This concentration will protect against acute effects in aquatic life and is the highest in stream concentration of a priority toxic pollutant consisting of a 1-hour average not to be exceeded more than once every 3 years on average.
CCC – criteria continuous concentration. This concentration will protect against chronic effects in aquatic life and is the highest in stream concentration of a priority toxic pollutant consisting of a 4-day average not to be exceeded more than once every 3 years on average.
NA – nothing available.
1 - Calculated from water toxicity data based on 1% organic matter according to Talmage. S.S., and D.M. Opresko, 1995, Draft Ecological Criteria Documents for Explosives, Oak Ridge National Laboratory, Oak Ridge, Tennessee.
2 - Smith, S.L., D.D. MacDonald, K.A. Keenleyside, C.G. Ingersoll, and L.J.Field, 1996, "a preliminary evaluation of sediment quality assessment values for freshwater ecosystems," J. Great Lakes Res. 22(3): 624-638.
3 - Ontario Ministry of the Environment and Energy, 1993, Guidelines for the Protection and Management of Aquatic Sediment Quality in Ontario, Water Resources Branch, Ontario Ministry of the Environment and Energy.
4 - Long, E.R., and L.G. Morgan, The Potential for Biological Effects of Sediment-sorbed Contaminants Tested in the National Status and Trends Program, NOAA, National Ocean Service, Seattle, Washington.
5 - Hardness dependent parameter. The criteria are as indicated at hardness of 100 mg/L as $CaCO_3$ but will be recalculated using site-specific hardness from each sampling location. The hardness dependent Federal water quality criteria are based on dissolved metals. The State hardness dependent water quality criteria are based on total recoverable metals.
6 - Lowest Observed Adverse Effect Level (LOAEL). Not enough data to develop criteria.
7 - Burrows, E.P., D.H. Rosenblatt, W.R. Mitchell, and D.L. Parmer, 1989, Organic Explosives and Related Compounds: Environmental and Health Considerations, U.S. Army Biomedical Research and Development Laboratory.
8 - Talmage, S.S., and D.M. Opresko. 1995. Draft Ecological Criteria Documents for Explosives, Prepared by Oak Ridge National Laboratory, Oak Ridge, Tennessee.
9 - U.S. Environmental Protection Agency, 1994, Water Quality Standards Handbook, Office of Water, Washington, D.C.
10 - Jones, D.S., G.W. Suter II, and R.N. Hull, 1997, Toxicological Benchmarks for Screening Contaminants of Potential Concern for Effects on Sediment-Associated Biota: 1997 Revision, report number ES/ER/TM-95/R4, prepared for the U.S. Department of Energy, Office of Environmental Management, prepared by Oak Ridge National Laboratory.
11 - U.S. Environmental Protection Agency, 1999, National Recommended Water Quality Criteria-Correction, USEPA 822-Z-99-001, Office of Water, Washington D.C.
12 - State of Indiana Title 327-Water Pollution Control Board, Article 2-Water Quality Standards Amended 4 February 2002.
13 – Based on National Secondary Drinking Water Regulations.

TABLE 8-4 FLOW FROM HARBERTS CREEK, CUBIC FEET PER SECOND, APRIL 01 2002 TO JANUARY 31 2003, MEAN DAILY VALUES

DATE	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan
1	3.9	6.1	1.4	0.97	0.01	0	0.66	2.5	1.8	243
2	3.3	29	1.3	0.72	0	0	0.45	2.2	1.6	41
3	3	9.6	1.1	0.58	0	0	0.38	2	1.5	20
4	2.7	4.9	0.94	0.45	0	0	0.86	1.7	1.3	12
5	2.3	3.5	1.1	0.33	0	0	1.3	4.9	1.6	9.2
6	2.1	**290**	18	0.24	0	0	0.79	9.1	1.4	7.5
7	1.9	**82**	5.7	0.26	0	0	**0.59**	3.5	1.4	5.9
8	1.9	**524**	2.8	0.2	0	0	**0.53**	2.6	1.5	5.3
9	2.6	**73**	1.9	2.6	0	0	**0.48**	2.6	1.5	4.7
10	2.5	22	1.5	2.6	0	0	**0.54**	162	1.5	3.7
11	2.1	12	1.2	0.64	0	0	**0.87**	71	24	2.7
12	2	10	2.5	0.33	0	0	0.81	15	26	2.4
13	82	423	6.2	0.26	0	0	0.59	8.4	39	2.1
14	111	46	6.1	0.25	0	0	0.48	5.9	34	2
15	27	16	2.5	0.15	0	5.6	0.46	4.9	14	1.9
16	9.8	9.7	2.2	0.07	0	**0.67**	0.45	4.5	8.9	1.7
17	6.1	35	1.5	0.21	0	**0.18**	0.39	3.6	8.2	1.5
18	4.7	40	1.2	2.2	0	**0.04**	0.31	2.9	12	1.4
19	3.8	11	0.88	3.2	0.05	**0.03**	0.66	2.6	226	1.4
20	8.6	7.4	0.71	0.96	0.08	0.17	1.1	2.4	107	1.4
21	335	5.6	0.58	0.44	0.03	1.1	0.77	2.5	23	1.2
22	145	4.5	0.5	0.5	0	0.39	0.58	5.7	12	1
23	14	3.7	0.44	0.28	0	0.12	0.45	3.9	7.8	0.9
24	25	3.1	0.39	0.23	0	0.04	0.37	2.9	6.8	0.59
25	64	2.7	5.9	0.11	0	0.01	42	2.4	12	1.1
26	9.5	2.5	9.8	0.1	0	0.19	13	2.2	7.8	0.94
27	43	3.1	6.8	0.09	0	573	3.9	2	5.7	0.89
28	153	2.3	6.6	0.08	0	13	2.4	1.9	5.4	1
29	15	2.4	2.3	0.07	0	2.5	21	1.9	6	1.4
30	7.4	2.1	1.4	0.05	0	1.2	9.4	2	55	1.3
31		1.7		0.04	0		4.1		131	1.2
COUNT	**30**	**31**	**30**	**31**	**31**	**30**	**31**	**30**	**31**	**31**
MAX	**335**	**524**	**18**	**3.2**	**0.08**	**573**	**42**	**162**	**226**	**243**
MIN	**1.9**	**1.7**	**0.39**	**0.04**	**0**	**0**	**0.31**	**1.7**	**1.3**	**0.59**

Bolded flows represent days when study team was at JPG. The first was the scoping visit (flooded conditions), the second was when sampling was postponed due to lack of flow, and the third was when sampling occurred.

Sample tubing was precleaned by the laboratory with acid wash prior to use in the field. A new pair of talc-free gloves was worn by sampling personnel at each sampling location. An in-situ multi-parameter data logger was used at each sampling location to record the ambient surface water dissolved oxygen, pH, conductivity, and temperature. The readings were transcribed into the field log sheet while onsite. The data logger was calibrated each day and checked at the end of each day against known standards.

8.3.3 Sediment Sampling

Sediment samples were collected from areas in the stream where an obstruction allowed a small amount to settle behind it. There was very little sediment to be found. The current scours the streambed to limestone bedrock. Approximately 10 composite sediment (mostly sand and grit) samples were collected with a precleaned disposable plastic scoop, placed in an aluminum foil-lined stainless steel bowl, homogenized, and scooped into the precleaned sample containers for each analytical grouping. A new pair of talc-free nitrile gloves was used for each sampling location. Sediment sampling occurred after surface water sample collection.

8.3.4 Benthic Macroinvertebrate Sampling

It is widely recognized that biota accurately reflect the quality of the environment they are subjected to. Therefore, biological indices/indicator organisms were collected at JPG as supporting data in evaluating if munitions-related constituents were adversely affecting the ecological health of the aquatic biota. The macroinvertebrate sampling rationale and its usefulness as an indicator of environmental quality is detailed in the QAPP. Benthic macroinvertebrates were collected at each sampling location by cleaning the attached organisms from rocks and cobble into a net or bucket. The normal consolidation of rocks forming a riffle was nearly nonexistent in the JPG streams. Individual rocks from large areas of the stream needed to be collected and cleaned of organisms. Three samples were collected from each sampling location (except for sampling locations 3, 8, and 9 where there were so few organisms and poor substrate, that sampling was suspended with one subsample). Samples were preserved onsite with 10% formalin and Rose Bengal dye to aid in later sorting. The samples were then sent to the contractor for identification to species or the lowest practicable taxonomic level.

8.3.5 Sample Labels and Identification

8.3.5.1 <u>Sample Labels</u>

Labels detailing the following information were affixed to each sample container prior to field activities: sample identification number, sampling location, date, sample parameter, preservation requirements, and sampling personnel. The same information, along with pertinent field observations, was recorded in the field logbook.

8.3.5.2 Sample Identification

8.3.5.2.1 Field Samples

The surface water and sediment samples collected at each sampling location were assigned specific four-digit identification numbers. The first two letters corresponded to the type of sample ("SW" denoted surface water while "SE" denoted sediment and SG denoted seep). The last two digits were sequential numbers of the samples starting with 01 and ending with 22, yielding 22 total surface water samples and 22 total sediment samples. A waterproof marker was used to label the sample bottles.

8.3.5.2.2 Blank Samples

Blank samples collected for QA/QC purposes were assigned unique sample identifications based on the type of blank collected. The blank identification numbers are listed below. A discussion of QA/QC sample collection and data is found in section 8.2.2.

- Equipment blank (surface water) – Equip. Blk-1 [(U)unfiltered and (F)filtered]
- Sediment equipment blank – Sed. Equip. Blk-1
- Container blank – Container Blk-1

8.3.5.2.3 Macroinvertebrate Samples

The benthic macroinvertebrate samples were labeled with the installation, preservative, type of sample, date collected, stream name, and sampling location number.

8.3.6 Field Notes and Photographic Documentation

Field data and observations at each sampling location were recorded in a field notebook. Stream data included: the date and time of sample collection, weather conditions, general site descriptions, in-situ data logger physical parameters (pH, temperature, conductivity and dissolved oxygen), identification of duplicate samples collected (where applicable), and any notes on surface water and sediment sample collection. Photographs of the sampling locations were also taken. Sampling location photographs and field notes are included in Appendix E.

8.3.7 Sample Management and Laboratory Analysis

8.3.7.1 Sample Collection and Preservation

All environmental samples were collected in accordance with USEPA and USACHPPM approved field procedures (QAPP). Samples that required preservatives were preserved onsite. Prior to shipment, samples were stored in ice chests with sufficient ice to maintain a temperature of 4^{o} Celsius. Macroinvertebrate samples were preserved onsite with formalin and Rose Bengal dye before shipment to the contractor.

8.3.7.2 Sample Handling and Shipment

All collected samples were stored in a secured building while awaiting shipment. Ice chests were used to ship the samples to the appropriate laboratory for analysis. Surface water and sediment samples for trace metals analysis were shipped to Battelle Laboratories in Sequim, Washington. Surface water and sediment samples for explosives and general parameters were shipped to USACHPPM Laboratories in Aberdeen Proving Ground, Maryland. Surface water and sediment for perchlorate were shipped to DATACHEM, Salt Lake City, Utah and total organic carbon and total organic matter were shipped to TriMatrix Laboratories, Inc., Grand Rapids Michigan. All ice chests were secured with strapping tape and custody seal, then shipped via Federal Express. Standardized field packing lists were included in each cooler, specifying the number and type of samples included in each cooler. The chain of custody and packing lists detailed the sample identification numbers, sample dates, and parameters to be analyzed.

A temperature control bottle was included in each cooler so that the temperature of the samples could be logged upon arrival at the laboratory. Macroinvertebrate samples were packed in separate coolers and shipped to Dr. James Matta, Milton, Pennsylvania (contractor) for picking, sorting and identification.

8.3.7.3 Laboratory Sample Receipt

All samples were received by the laboratories in satisfactory timeliness and condition except for the following:

- The explosives sediment samples shipped 10 October 2002 were delivered to the wrong building and sat over the weekend before discovery. The sample temperature was >4^{o}C when received. The sampling locations were SE-(01, 02, 03, 04, 05, 10, 11, 12, 13, 14, 15, 16, 19, and 20).

8.4 FIELD INVESTIGATION RESULTS AND DISCUSSION

See Figure 8-1 for JPG sampling locations and Tables 8-5, 8-6, and 8-7 for complete chemical, physical and a summary of biological results. For the complete benthic macroinvertebrate results see Appendix F. The first and most important evaluation of the results was comparing the results to Federal WQC, State WQSs, and SQBs. The exceedances are highlighted in the tables and are discussed below.

- There were exceedances of the National Secondary Drinking Water Standard of 50 µg/L dissolved manganese in the water at sampling locations 03 (69.6 µg/L), 06 (50.7 µg/L), 10 (55.5 µg/L), 11 (72.7 µg/L), and 15 (410 µg/L). Sampling locations 10 and 11 were upstream reference locations. The drinking water standard for dissolved manganese is based on taste, staining, and deposition in drinking water systems. Since the surface water at JPG is not used for drinking it is of little concern. The lowest observed effect concentration of manganese to freshwater organisms was 1,500 µg/L (USEPA-440/9-76-023, Quality Criteria for Water).

TABLE 8-5. COMPLETE SURFACE WATER RESULTS, JPG FIRING RANGE STUDY, 7-11 OCTOBER 2002

PARAMETER	UNIT	SW-01	SW-02	SW-03	SW-04**, ***	SW-05**	SW-06**, ***	Reference SW-07	Reference SW-08	Reference SW-09	Reference SW-10	Reference SW-11	Reference SW-12	REGULATORY CRITERIA* FEDERAL AMBIENT WATER QUALITY CRITERIA CMC	CCC	INDIANA AMBIENT WATER QUALITY STANDARDS CMC	CCC
Explosives and Degradates																	
HMX	µg/L	3.0 U	3.0 U	3.0 U	3.0 U	3.0 U	3.0 U	3.0 U	3.0 U	3.0 U	3.0 U	3.0 U	3.0 U	NA	330		
RDX	µg/L	0.190	0.140	0.027 J	0.100 U	0.039 J	0.100 U	0.100 U	0.100 U	0.023 J	0.072 J	0.036 J	0.040 J	4000	190		
2,4,6-TNT	µg/L	0.030 U	0.030 U	0.030 U	0.030 U	0.030 U	0.030 U	0.030 U	0.030 U	0.030 U	0.030 U	0.030 U	0.030 U	570	130		
1,3-DNB	µg/L	0.090 U	0.090 U	0.090 U	0.090 U	0.090 U	0.090 U	0.090 U	0.090 U	0.090 U	0.090 U	0.090 U	0.090 U	110	30		
1,3,5-TNB	µg/L	0.030 U	0.030 U	0.030 U	0.030 U	0.030 U	0.030 U	0.030 U	0.030 U	0.030 U	0.030 U	0.030 U	0.030 U	30	14		
TETRYL	µg/L	0.50 U	0.50 U	0.50 U	0.50 U	0.50 U	0.50 U	0.50 U	0.50 U	0.50 U	0.50 U	0.50 U	0.50 U	NA	NA		
NB	µg/L	0.030 U	0.030 U	0.030 U	0.030 U	0.030 U	0.030 U	0.030 U	0.030 U	0.030 U	0.030 U	0.030 U	0.030 U	27,000			
2A-4,6-DNT	µg/L	0.10 U	0.10 U	0.10 U	0.10 U	0.10 U	0.10 U	0.10 U	0.10 U	0.10 U	0.10 U	0.10 U	0.10 U	NA	NA	No numeric criteria have been established for these compounds.	
4A-2,6-DNT	µg/L	0.10 U	0.10 U	0.10 U	0.10 U	0.10 U	0.10 U	0.10 U	0.10 U	0.10 U	0.10 U	0.10 U	0.10 U	NA	NA		
2,6-DNT	µg/L	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	18,500	NA		
2,4-DNT	µg/L	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	330	230		
2-NT	µg/L	0.090 U	0.090 U	0.090 U	0.090 U	0.090 U	0.090 U	0.090 U	0.090 U	0.090 U	0.090 U	0.090 U	0.090 U	NA	NA		
3-NT	µg/L	0.090 U	0.090 U	0.090 U	0.090 U	0.090 U	0.090 U	0.090 U	0.090 U	0.090 U	0.090 U	0.090 U	0.090 U	NA	NA		
4-NT	µg/L	0.090 U	0.090 U	0.090 U	0.090 U	0.090 U	0.090 U	0.090 U	0.090 U	0.090 U	0.090 U	0.090 U	0.090 U	NA	NA		
Nitroglycerin	µg/L	0.090 U	0.090 U	0.090 U	0.090 U	0.090 U	0.090 U	0.090 U	0.090 U	0.090 U	0.090 U	0.090 U	0.090 U	1700	200		
WP	µg/L	0.024 U	0.024 U	0.024 U	0.024 U	0.024 U	0.024 U	0.024 U	0.024 U	0.024 U	0.024 U	0.024 U	0.024 U	0.5	0.1		
Metals																	
Hardness	mg/L	141	125	120	128	160	149	172	208	156	160	116	148	-	-	-	-
Antimony (Total/*Dissolved*)	µg/L	0.0877 *0.0992*	0.0860 *0.0895*	0.0599 *0.0644*	0.0792 *0.0836*	0.0964 *0.0993*	0.0814 *0.0856*	0.0924 *0.0913*	0.0734 *0.0651*	0.0957 *0.0886*	0.1230 *0.1110*	0.1510 *0.1580*	0.0861 *0.0844*	- 180	- 30	-	-
Arsenic	µg/L	0.420 *0.436*	0.917 *0.873*	0.688 *0.678*	0.758 *0.771*	1.220 *1.160*	0.914 *0.989*	1.160 *1.290*	0.808 *0.896*	0.917 *1.150*	1.180 *1.090*	1.050 *0.997*	0.785 *0.738*	- 340	- 150	360 -	190 -
Barium	µg/L	66.6 *66.4*	52.5 *47.8*	78.5 *75.5*	44.6 *44.1*	52.3 *52.8*	45.0 *45.0*	52.9 *51.2*	58.2 *57.3*	65.3 *62.6*	58.4 *58.1*	56.5 *54.9*	55.2 *53.7*	- 1000	1000	- -	- -
Cadmium	µg/L	0.06610 *0.34400*	0.03220 *0.01190*	0.01480 *0.00885*	0.00959 *0.00989*	0.01380 *0.01220*	0.01140 *0.00670*	0.00963 *0.01040*	0.06130 *0.02530*	0.13600 *0.01880*	0.01700 *0.08690*	0.01980 *0.02210*	0.01740 *0.01610*	- 4.3	- 2.2	4 -	1.1 -
Calcium	µg/L	35500 *35800*	34600 *34500*	32300 *32600*	36300 *36400*	46600 *46700*	46400 *46300*	51900 *51800*	57100 *57100*	44800 *44300*	53400 *45600*	33300 *33300*	43900 *43600*	- -	- -	- -	- -
Chromium	µg/L	0.3580 *0.3020*	0.4620 *0.0240 U*	0.0240 U *0.0240 U*	0.0240 U *0.0240 U*	0.3110 *0.2370*	0.3110 *0.2100*	0.4080 *0.3940*	0.5220 *0.8110*	0.2920 *0.4030*	0.2980 *0.3160*	0.7540 *0.1250*	0.3390 *0.2900*	- 570	- 74	1737 -	207 -
Copper	µg/L	1.240 *1.260*	1.460 *1.190*	0.698 *0.592*	1.110 *1.050*	1.050 *0.965*	0.864 *0.871*	0.989 *0.968*	0.614 *0.600*	1.180 *1.180*	1.120 *1.030*	1.370 *1.260*	1.120 *1.140*	- 13	- 9	18 -	9 -
Lead	µg/L	0.03100 *0.00500 U*	1.46000 *0.00795*	0.15400 *0.00500 U*	0.05550 *0.00500 U*	0.10300 *0.01920*	0.07200 *0.00935*	0.05780 *0.01890*	0.07110 *0.00830*	0.04080 *0.00500 U*	0.07490 *0.01300*	2.01000 *0.03410*	0.23500 *0.22500*	- 65	- 2.5	82 -	3 -
Magnesium	µg/L	12600 *12600*	9400 *9370*	9250 *9380*	8910 *8910*	10200 *10400*	8000 *8170*	10300 *10300*	16400 *15800*	11200 *11000*	13500 *11400*	8050 *8100*	9560 *9550*	- -	- -	- -	- -
Manganese	µg/L	5.28 *2.84*	113.00 *17.00*	120.00 *69.60*	31.70 *23.70*	42.30 *8.87*	50.60 *50.70*	27.70 *11.40*	50.10 *39.70*	78.80 *22.70*	56.60 *55.50*	89.20 *72.70*	37.10 *34.90*	- 50	- -	- -	- -
Mercury	µg/L	0.001050 *0.000958*	0.003640 *0.002270*	0.002340 *0.001640*	0.001970 *0.001830*	0.002010 *0.001310*	0.001600 *0.001200*	0.001700 *0.001330*	0.000890 *0.000860*	0.002280 *0.002020*	0.001820 *0.001350*	0.001870 *0.001330*	0.002140 *0.002160*	- 1.4	- 0.77	2.4 -	0.012 -
Molybdenum	µg/L	0.673 *0.695*	0.397 *0.473*	0.403 *0.413*	0.479 *0.502*	0.994 *0.980*	0.745 *0.683*	0.928 *0.861*	1.070 *1.020*	1.650 *1.380*	1.330 *1.310*	0.858 *0.845*	0.493 *0.565*	- 16000	- 370	- -	- -
Nickel	µg/L	1.48 *1.45*	2.07 *1.70*	1.65 *1.55*	1.72 *1.54*	2.04 *1.98*	2.04 *2.19*	2.23 *2.48*	2.43 *2.44*	2.33 *2.35*	2.42 *2.52*	1.75 *1.67*	2.01 *2.28*	- 470	- 52	1418 -	158 -
Silver	µg/L	0.02710 B *0.04800 B*	0.02640 B *0.02310 B*	0.01400 B *0.01250 B*	0.18200 *0.20900*	0.07600 *0.09900*	0.01280 B *0.01410 B*	0.01220 B *0.00400 U*	0.04300 B *0.00401 B*	0.01860 B *0.00400 U*	0.01010 B *0.00685 B*	0.22000 *0.25800*	0.00858 B *0.00841B*	- 3.4	- -	2 -	- -
Uranium	µg/L	0.636 *0.654*	1.140 *1.060*	0.236 *0.231*	0.312 *0.319*	0.434 *0.420*	0.379 *0.374*	0.510 *0.483*	0.796 *0.779*	1.110 *1.040*	0.580 *0.575*	0.665 *0.650*	0.640 *0.653*	- 46	- 2.6	- -	- -
Vanadium	µg/L	0.263 *0.233*	1.340 *0.537*	0.303 *0.107*	0.441 *0.371*	0.822 *0.672*	0.629 *0.526*	0.707 *0.632*	0.562 *0.485*	0.629 *0.567*	0.739 *0.622*	1.430 *0.983*	0.784 *0.688*	- 280	- 20	- -	- -
Zinc	µg/L	0.487 *0.480*	3.680 *0.423*	1.260 *0.370*	0.628 *0.293*	0.802 *0.596*	1.250 *0.216*	1.180 *0.702*	2.180 *1.210*	1.870 *1.020*	1.010 *4.410*	1.740 *0.484*	1.460 *1.660*	- 120	- 120	117 -	106 -
Other Parameters																	
Perchlorate	µg/L	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	5000	600	-	-
TOC	mg/L	3.7	6.4	6.8	6.0	8.2	5.9	6.5	3.2	8.3	7.0	6.1	5.6	-	-	-	-
pH (Field, Lab)	s.u.	7.5	7.28	6.98	7.57	7.91	8.12	8.17	7.55	7.15	7.69	7.69	8.22	6.5 - 9.0		-	
D.O. (Field)	mg/L	6.5	2.91	2.7	9.5	10.39	2.17	11.24	10.51	7.37	8.14	8.4	13.21	-	-	-	-
Conductivity (Field)	µ-ohm	238	208	205	231	355	262	319	369	271	407	407	290	-	-	-	-
Temperature (Field)	Deg.Cel.	11.02	14.61	16.29	13.66	13.75	16.9	16.55	15.68	15.38	14.2	14.2	14.39	-	-	-	-

*-For complete citations see Table 8-3. **-19 was a duplicate **for 16, 20 was a duplicate for 04, 21 was a split for 05, and 22 was a split for 06.** ***-No parameter was higher than average reference value. Underlining-represents results substantially above reference (above all reference values). **Bold**-represents results above detection limit. **B**-represents parameter was also detected in laboratory blank for that run. **J**-estimate value below reporting limit. **NA**-not available. **U**-under detection limit.

Highlighted represents exceedance of WQC

TABLE 8-5. COMPLETE SURFACE WATER RESULTS, JPG FIRING RANGE STUDY, 7-11 OCTOBER 2002 (CONTINUED)

PARAMETER	UNIT	SW-13	SW-14	SW-15	SW-16	SW-17**	SW-18**	Duplicate for SW-16 SW-19	Duplicate for SW-04 SW-20	Split for SW-05 SW-21	Split for SW-06 SW-22	Seep (spring) SG-01	REGULATORY CRITERIA* FEDERAL AMBIENT WATER QUALITY CRITERIA CMC	CCC	INDIANA AMBIENT WATER QUALITY CRITERIA CMC	CCC
Explosives and Degradates																
HMX	µg/L	3.0 U	3.0 U	3.0 U	3.0 U	3.0 U	3.0 U	3.0 U	3.0 U	3.0 U	3.0 U	3.0 U	NA	330		
RDX	µg/L	**0.025 J**	0.100 U	**0.037 J**	**0.13**	0.100 U	0.100 U	**0.051 J**	0.100 U	**0.031 J**	**0.021 J**	0.100 U	4000	190		
2,4,6-TNT	µg/L	0.030 U	0.030 U	0.030 U	0.030 U	0.030 U	0.030 U	0.030 U	0.030 U	0.030 U	0.030 U	0.030 U	570	130		
1,3-DNB	µg/L	0.090 U	0.090 U	0.090 U	0.090 U	0.090 U	0.090 U	0.090 U	0.090 U	0.090 U	0.090 U	0.090 U	110	30		
1,3,5-TNB	µg/L	0.030 U	0.030 U	0.030 U	0.030 U	0.030 U	0.030 U	0.030 U	0.030 U	0.030 U	0.030 U	0.030 U	30	14		
TETRYL	µg/L	0.50 U	0.50 U	0.50 U	0.50 U	0.50 U	0.50 U	0.50 U	0.50 U	0.50 U	0.50 U	0.50 U	NA	NA		
NB	µg/L	0.030 U	0.030 U	0.030 U	0.030 U	0.030 U	0.030 U	0.030 U	0.030 U	0.030 U	0.030 U	0.030 U	27,000			
2A-4,6-DNT	µg/L	0.10 U	0.10 U	0.10 U	0.10 U	0.10 U	0.10 U	0.10 U	0.10 U	0.10 U	0.10 U	0.10 U	NA	NA	No numeric criteria have been established for these compounds.	
4A-2,6-DNT	µg/L	0.10 U	0.10 U	0.10 U	0.10 U	0.10 U	0.10 U	0.10 U	0.10 U	0.10 U	0.10 U	0.10 U	NA	NA		
2,6-DNT	µg/L	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	18,500	NA		
2,4-DNT	µg/L	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	330	230		
2-NT	µg/L	0.090 U	0.090 U	0.090 U	0.090 U	0.090 U	0.090 U	0.090 U	0.090 U	0.090 U	0.090 U	0.090 U	NA	NA		
3-NT	µg/L	0.090 U	0.090 U	0.090 U	0.090 U	0.090 U	0.090 U	0.090 U	0.090 U	0.090 U	0.090 U	0.090 U	NA	NA		
4-NT	µg/L	0.090 U	0.090 U	0.090 U	0.090 U	0.090 U	0.090 U	0.090 U	0.090 U	0.090 U	0.090 U	0.090 U	NA	NA		
Nitroglycerin	µg/L	0.090 U	0.090 U	0.090 U	0.090 U	0.090 U	0.090 U	0.090 U	0.090 U	0.090 U	0.090 U	0.090 U	1700	200		
WP	µg/L	0.024 U	0.024 U	0.024 U	0.024 U	0.024 U	0.024 U	0.024 U	0.024 U	0.024 U	0.024 U	0.026 U	0.5	0.1		
Metals																
Hardness	mg/L	**116**	**120**	**128**	**175**	**98**	**144**	**175**	**128**	**156**	**148**	**198**	-	-	-	-
Antimony (Total/*Dissolved*)	µg/L	**0.0937** ***0.0644***	**0.0830** ***0.0820***	**0.0703** ***0.0864***	**0.1300** ***0.1010***	**0.0611** ***0.0616***	**0.0733** ***0.0711***	**0.1090** ***0.1150***	**0.0947** ***0.1080***	**0.0946** ***0.0967***	**0.0781** ***0.0793***	**0.0207 B** ***0.0143 B***	- 180	- 30	-	-
Arsenic	µg/L	**0.572** ***0.329***	**0.747** ***0.777***	**2.000** ***1.340***	**1.530** ***1.360***	**0.773** ***0.791***	**0.839** ***0.906***	**1.450** ***1.370***	**0.740** ***0.713***	**1.150** ***1.190***	**0.900** ***1.040***	**0.385** ***0.210***	- 340	- 150	360 -	190 -
Barium	µg/L	**122.0** ***49.0***	**43.8** ***45.0***	**111.0** ***72.9***	**57.0** ***53.4***	**37.4** ***34.9***	**44.9** ***42.7***	**54.7** ***53.7***	**44.8** ***44.1***	**52.2** ***51.4***	**45.9** ***44.2***	**46.2** ***43.7***	- 1000	1000	- -	- -
Cadmium	µg/L	**0.10100** ***0.01080***	**0.00991** ***0.00922***	**0.02100** ***0.01870***	**0.02310** ***0.01520***	**0.00790** ***0.01070***	**0.01190** ***0.01020***	**0.01460** ***0.01030***	**0.01280** ***0.00671***	**0.00875** ***0.01030***	**0.01020** ***0.00709***	**0.06020** ***0.07270***	- 4.3	- 2.2	4 -	1.1 -
Calcium	µg/L	**92900** ***27300***	**34700** ***36100***	**39600** ***39000***	**50900** ***50000***	**30000** ***30300***	**45300** ***44500***	**50500** ***49900***	**37000** ***36400***	**46000** ***45800***	**46200** ***45800***	**49800** ***50400***	- -	- -	- -	- -
Chromium	µg/L	**0.0309** *0.0240 U*	**0.1770** ***0.0384***	0.0240 U *0.0240 U*	**0.5750** ***0.3990***	**0.3430** ***0.2500***	**0.2320** ***0.2740***	**0.4540** ***0.3220***	**0.0322** *0.0240 U*	**0.3180** ***0.2380***	**0.3090** ***0.2940***	**0.4380** ***0.1650***	- 570	- 74	1737 -	207 -
Copper	µg/L	**5.520** ***0.657***	**1.310** ***1.240***	**0.758** ***0.893***	**1.270** ***0.951***	**0.549** ***0.526***	**0.811** ***0.780***	**1.100** ***0.989***	**1.090** ***1.030***	**1.030** ***0.935***	**0.846** ***0.943***	**0.477** ***0.250***	- 13	- 9	18 -	9 -
Lead	µg/L	**0.09770** *0.00500 U*	**0.03660** ***0.00569***	**0.10000** ***0.02270***	**0.37300** ***0.00500 U***	**0.18800** ***0.03220***	**0.07320** ***0.01730***	**0.14600** ***0.00500 U***	**0.03320** ***0.00500 U***	**0.08630** ***0.00936***	**0.05620** ***0.01530***	**0.42500** *0.005 U*	- 65	- 2.5	82 -	3 -
Magnesium	µg/L	**13100** ***11600***	**7670** ***7830***	**7520** ***7420***	**12400** ***12200***	**5340** ***5460***	**7950** ***7920***	**12300** ***12100***	**9090** ***9130***	**10200** ***10100***	**7990** ***8160***	**17700** ***17800***	- -	- -	- -	- -
Manganese	µg/L	**251.00** ***4.65***	**38.40** ***34.60***	**939.00** ***401.00***	**99.40** ***8.48***	**37.10** ***20.20***	**57.70** ***42.10***	**42.80** ***7.79***	**29.00** ***24.90***	**40.20** ***7.17***	**54.00** ***22.90***	**51.50** ***18.80***	- 50	- -	- -	- -
Mercury	µg/L	**0.001740** ***0.001100***	**0.002070** ***0.001950***	**0.001640** ***0.001560***	**0.003130** ***0.001630***	**0.001810** ***0.001510***	**0.001570** ***0.001320***	**0.002340** ***0.001480***	**0.001890** ***0.001660***	**0.002100** ***0.001380***	**0.001590** ***0.001270***	**0.001980** ***0.000523***	- 1.4	- 0.77	2.4 -	0.012 -
Molybdenum	µg/L	**0.218** ***0.260***	**0.463** ***0.472***	**0.527** ***0.529***	**1.160** ***1.200***	**0.455** ***0.454***	**0.661** ***0.621***	**1.210** ***1.230***	**0.498** ***0.479***	**0.991** ***0.963***	**0.749** ***0.714***	**0.147** ***0.182***	- 16000	- 370	- -	- -
Nickel	µg/L	**3.70** ***1.14***	**1.85** ***1.72***	**1.58** ***1.58***	**2.46** ***2.28***	**1.51** ***1.46***	**2.02** ***2.01***	**2.40** ***2.26***	**1.60** ***1.57***	**2.04** ***1.87***	**2.04** ***2.35***	**2.31** ***1.90***	- 470	- 52	1418 -	158 -
Silver	µg/L	**0.04670 B** ***0.02390 B***	**0.01050 B** ***0.01160 B***	**0.24900** ***0.24300***	**0.01990 B** ***0.00816 B***	**0.01670 B** ***0.02160 B***	**0.01370 B** ***0.01810 B***	**0.00928 B** ***0.00957 B***	**0.15400** ***0.17100***	**0.10500** ***0.12700***	**0.01150 B** ***0.00526 B***	**0.0316 B** ***0.0149 B***	- 3.4	- -	2 -	- -
Uranium	µg/L	**0.353** ***0.368***	**4.080** ***4.330***	**0.253** ***0.327***	**0.547** ***0.516***	**0.174** ***0.161***	**0.344** ***0.325***	**0.528** ***0.521***	**0.320** ***0.313***	**0.436** ***0.412***	**0.388** ***0.371***	**1.030** ***1.010***	- 46	- 2.6	- -	- -
Vanadium	µg/L	**0.326** ***0.132***	**0.631** ***0.582***	**0.475** ***0.450***	**1.220** ***0.801***	**0.588** ***0.328***	**0.546** ***0.446***	**1.010** ***0.813***	**0.431** ***0.370***	**0.807** ***0.661***	**0.625** ***0.523***	**0.775** ***0.241***	- 280	- 20	- -	- -
Zinc	µg/L	**12.500** ***0.393***	**0.750** ***0.458***	**1.100** ***0.450***	**1.590** ***2.400***	**1.020** ***0.455***	**1.580** ***0.287***	**0.941** ***0.605***	**1.670** ***0.335***	**0.658** ***0.517***	**0.588** ***0.475***	**3.500** ***1.410***	- 120	- 120	117 -	106 -
Other Parameters																
Perchlorate	µg/L	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	5000	600	-	-
TOC	mg/L	**3.2**	**5.6**	**6.8**	**9.0**	**7.0**	**5.4**	**9.1**	**6.1**	**8.2**	**5.8**	**1.1**	-	-	-	-
pH (Field, Lab)	s.u.	7.7	7.88	7.62	8.07	8.14	7.95	8.07	7.6	7.91	8.12	6.85	6.5 - 9.0		-	
D.O. (Field)	mg/L	8.9	11.2	8.4	11.12	7.1	2.41	11.12	9.17	10.76	2.17	0.61	-	-	-	-
Conductivity (Field)	µ-ohm	203	220	14.57	400	170	257	400	231	355	262	379	-	-	-	-
Temperature (Field)	Deg. Cel.	12.37	14.53	259	13.36	16.34	16.15	13.36	13.66	13.69	16.9	15.09	-	-	-	-

*-For complete citations see Table 8-3. ** No parameter was higher than the average reference value. Underlining-represents results substantially above reference (above all reference values). **Bold**-represents results above detection limit. **B**-represents parameter was also detected in laboratory blank for that run. **J**-estimate value below reporting limit. **NA**-not available. **U**-under detection limit.

Highlighted represents exceedance of WQC

TABLE 8-6. COMPLETE SEDIMENT RESULTS FOR JPG FIRING RANGE STUDY, 7-11 OCTOBER 2002

PARAMETER	UNIT	SE-01	SE-02	SE-03	SE-04**	SE-05**	SE-06**	Reference SE-07	Reference SE-08	Reference SE-09	Reference SE-10	Reference SE-11	Reference SE-12	REGULATORY CRITERIA* SEDIMENT QUALITY BENCHMARK
Explosives and Degradates														
HMX	µg/g	0.050 U	0.050 U	0.050 U	0.050 U	0.050 U	0.080	0.091	0.260	0.050 U	0.050 U	0.050 U	0.050 U	0.330[1]
RDX	µg/g	0.031	0.280	0.009 J	0.190	0.120	0.260	0.420	1.900	0.098	0.220	0.350	0.280	0.190[1]
2,4,6-TNT	µg/g	0.010 U	0.047	0.010 U	0.040	0.020	0.046	0.086	0.280	0.200	0.034	0.054	0.047	0.52[1]
1,3-DNB	µg/g	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.04[1]
1,3,5-TNB	µg/g	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.02[1]
TETRYL	µg/g	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	NA
NB	µg/g	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	27.0[1]
2A-4,6-DNT	µg/g	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	NA
4A-2,6-DNT	µg/g	0.050 U	0.050 U	0.050 U	0.050 U	0.050 U	0.050 U	0.050 U	0.050 U	0.050 U	0.050 U	0.050 U	0.050 U	NA
2,6-DNT	µg/g	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	18.5[1]
2,4-DNT	µg/g	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.230[1]
2-NT	µg/g	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	NA
3-NT	µg/g	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	NA
4-NT	µg/g	0.040 U	0.060 U	0.040 U	0.070 U	0.050 U	0.080 U	0.070 U	0.070 U	0.050 U	0.060 U	0.070 U	0.060 U	NA
Nitroglycerin	µg/g	0.050 U	0.050 U	0.050 U	0.050 U	0.050 U	0.050 U	0.050 U	0.050 U	0.050 U	0.050 U	0.050 U	0.050 U	NA
WP	µg/g	0.0010 U	0.0010 U	0.0010 U	0.0010 U	0.0010 U	0.0010 U	0.0010 U	0.0010 U	0.0010 U	0.0010 U	0.0010 U	0.0010 U	0.26[5]
Moisture (WP only)	Percent	20	20	20	20	15	19	21	11	18	22	20	22	NA
Metals														
Antimony	µg/g	0.407	0.259	0.185	0.365	0.186	0.253	0.271	0.348	0.195	0.141	0.196	0.31	NA
Arsenic	µg/g	13.10	7.71	6.68	8.02	4.71 B	20.20	3.79 B	6.45	3.70 B	7.68	3.40 B	9.64	5.9[2]
Barium	µg/g	189	200	165	183	212	318	246	180	243	261	159	149	500[3]
Cadmium	µg/g	0.219 B	0.0955 B	0.0927 B	0.133 B	0.0669 B	0.0587 U	0.103 B	0.0955 B	0.0964 B	0.0822 B	0.0823 B	0.108 B	0.596[2]
Chromium	µg/g	31.20	11.70	9.98	19.40	11.40	18.20	17.50	11.90	7.53	9.40	8.61	12.70	26[3]
Copper	µg/g	5.20	2.77	2.83	3.63	2.37	3.59	3.07	4.61	3.85	8.20	2.28	3.07	16[3]
Lead	µg/g	15.10	8.46	4.88	7.76	6.03	10.50	6.84	11.50	7.03	7.85	4.80	9.04	31[3]
Manganese	µg/g	500	239	143	391	183	326	154	496	237	235	143	327	460[3]
Mercury	µg/g	0.00630 J	0.01040	0.08700	0.01740	0.01450	0.00710 B,J	0.01350 B	0.01600 B	0.01910 B	0.01020	0.01380	0.01380	0.174[2]
Molybdenum	µg/g	1.330	0.782	0.550	1.150	0.516	0.868	0.837	1.150	0.452	0.486	0.642	0.881	NA
Nickel	µg/g	5.26	4.14	2.33	8.27	3.34	5.73	5.24	6.61	3.08	4.06	2.42	3.69	16[3]
Silver	µg/g	0.1350	0.0465	0.0416	0.1100	0.0593	0.0803	0.0729	0.1350	0.0485	0.1060	0.1460	0.1020	1[4]
Uranium	µg/g	0.599	0.517	0.354	0.516	0.286	0.719	0.357	0.948	0.682	0.436	0.416	0.531	NA
Vanadium	µg/g	37.0	23.4	15.2	35.4	15.8	25.8	21.7	25.5	16.1	13.9	27.3	27.6	NA
Zinc	µg/g	33.2	21.7	17.1	24.3	18.6	44.6	16.7	23.8	19.2	16.0	15.6	21.7	120[3]
Moisture	Percent	19.9	21.5	21.2	18.7	18.2	20.1	20.7	12.0	20.8	20.7	17.1	20.2	NA
Other Parameters														
Total Organic Matter	Percent	1.1	0.7	0.7	0.8	0.5	0.9	0.6	1.6	0.6	0.6	0.7	0.8	NA
Perchlorate	µg/g	0.013 U	0.013 U	0.013 U	0.012 U	0.013 U	0.013 U	0.013 U	0.011 U	0.013 U	0.013 U	0.013 U	0.013 U	NA

*-For complete citations see Table 8-3. **-19 was a duplicate for 16, 20 was a duplicate for 04, 21 was a split for 05, and 22 was a split for 06. Underlining-represents results substantially above reference (above all reference values). **Bold**-represents results above detection limit. **B**-represents parameter was also detected in laboratory blank for that run. **J**-estimate value below reporting limit. **NA**-not available. **U**-under detection limit.

Highlighted represents exceedance of SQB

TABLE 8-6. COMPLETE SEDIMENT RESULTS FOR JPG FIRING RANGE STUDY, 7-11 OCTOBER 2002

PARAMETER	UNIT	SE-13	SE-14	SE-15	SE-16	SE-17	SE-18	Duplicate for 16 SE-19	Duplicate for 04 SE-20	Duplicate for 05 SE-21	Duplicate for 06 SE-22	REGULATORY CRITERIA* SEDIMENT QUALITY BENCHMARK
Explosives and Degradates												
HMX	µg/g	**0.140**	0.050 U	0.050 U	**0.320**	**0.04 J**	0.050 U	0.050 U	0.050 U	0.050 U	**0.046 J**	0.330[1]
RDX	µg/g	**0.300**	**0.220**	**0.110**	**1.100**	**0.260**	**0.120**	0.010 U	**0.140**	0.010 U	**0.250**	0.190[1]
2,4,6-TNT	µg/g	**0.050**	**0.051**	**0.038**	**0.130**	**0.043**	**0.016**	**0.018**	**0.030**	**0.007 J**	**0.040**	0.52[1]
1,3-DNB	µg/g	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.04[1]
1,3,5-TNB	µg/g	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.02[1]
TETRYL	µg/g	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	NA
NB	µg/g	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	27.0[1]
2A-4,6-DNT	µg/g	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	NA
4A-2,6-DNT	µg/g	0.050 U	0.050 U	0.050 U	0.050 U	0.050 U	0.050 U	0.050 U	0.050 U	0.050 U	0.050 U	NA
2,6-DNT	µg/g	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	18.5[1]
2,4-DNT	µg/g	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.230[1]
2-NT	µg/g	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	NA
3-NT	µg/g	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	NA
4-NT	µg/g	0.070 U	0.070 U	0.060 U	0.060 U	0.070 U	0.050 U	0.050 U	0.070 U	0.020 U	0.070 U	NA
Nitroglycerin	µg/g	0.050 U	0.050 U	0.050 U	0.050 U	0.050 U	0.050 U	0.050 U	0.050 U	0.050 U	0.050 U	NA
WP	µg/g	0.0010 U	0.0010 U	0.0010 U	0.0010 U	0.0010 U	0.0010 U	0.0010 U	0.0010 U	0.0010 U	0.0010 U	0.26[5]
Moisture (WP only)	Percent	20	15	18	20	21	22	20	20	17	18	NA
Metals												
Antimony	µg/g	**0.474**	**0.485**	**0.323**	**0.151**	**0.280**	**0.217**	**0.162**	**0.259**	**0.172**	**0.343**	NA
Arsenic	µg/g	**8.82**	**23.80**	**11.40**	**4.84 B**	**5.52 B**	**15.90**	**4.26 B**	**9.28**	**6.96**	**18.70**	5.9[2]
Barium	µg/g	**210**	**263**	**242**	**229**	**249**	**219**	**230**	**196**	**210**	**287**	500[3]
Cadmium	µg/g	**0.1780 B**	0.0587 U	**0.1770 B**	**0.1060 B**	**0.1580 B**	0.0587 U	**0.1010 B**	**0.0945 B**	0.0587 U	0.0587 U	0.596[2]
Chromium	µg/g	**23.5**	**24.9**	**23.0**	**11.5**	**19.6**	**14.2**	**18.5**	**13.4**	**12.6**	**33.6**	26[3]
Copper	µg/g	**9.65**	**5.72**	**4.50**	**3.86**	**5.95**	**2.11**	**3.43**	**3.79**	**3.14**	**3.59**	16[3]
Lead	µg/g	**19.40**	**11.70**	**12.30**	**7.36**	**10.90**	**6.72**	**7.64**	**7.59**	**8.52**	**10.20**	31[3]
Manganese	µg/g	**743**	**639**	**392**	**310**	**434**	**219**	**225**	**325**	**230**	**298**	460[3]
Mercury	µg/g	**0.00990 J**	**0.02110 B**	**0.02390**	**0.00800 J**	**0.02030**	**0.02120 B**	**0.01030**	**0.01360**	**0.00840 J**	**0.01160 B**	0.174[2]
Molybdenum	µg/g	**1.120**	**1.470**	**1.000**	**0.329**	**0.606**	**0.554**	**0.438**	**0.802**	**0.476**	**0.897**	NA
Nickel	µg/g	**6.19**	**6.72**	**6.71**	**3.04**	**5.86**	**4.53**	**3.32**	**4.42**	**3.38**	**5.72**	16[3]
Silver	µg/g	**0.0660**	**0.0674**	**0.1120**	**0.0545**	**0.0985**	**0.0592**	**0.0846**	**0.0606**	**0.0899**	**0.0625**	1[4]
Uranium	µg/g	**0.629**	**3.050**	**0.666**	**0.646**	**0.964**	**0.462**	**0.618**	**0.504**	**0.338**	**0.755**	NA
Vanadium	µg/g	**25.2**	**49.4**	**35.1**	**17.5**	**26.8**	**23.0**	**15.1**	**20.8**	**17.7**	**26.4**	NA
Zinc	µg/g	**51.6**	**45.8**	**28.4**	**22.8**	**35.2**	**31.6**	**20.1**	**23.4**	**19.7**	**42.5**	120[3]
Moisture	Percent	22.8	20.7	17.2	21.9	26.8	20.6	18.3	18.4	17.9	20.7	NA
Other Parameters												
Total Volatile Solids	Percent	0.9	0.9	1.2	0.8	1.7	0.4	0.5	0.9	0.5	0.9	NA
Perchlorate	µg/g	0.013 U	0.013 U	0.012 U	0.013 U	0.012 U	0.013 U	0.013 U	0.012 U	0.013 U	0.012 U	NA

*-For complete citations see Table 8-3. Underlining-represents results substantially above reference (above all reference values). **Bold**-represents results above detection limit. **B**-represents parameter was also detected in laboratory blank for that run. **J**-estimate value below reporting limit. **NA**-not available. **U**-under detection limit.

Highlighted represents exceedance of SQB

TABLE 8-7 BENTHIC MACROINVERTEBRATE RESULTS, JPG FIRING RANGE STUDY, 7-11 OCTOBER 2002

Genus species	1A	1B	1C	1ABC	2A	2B	2C	2ABC	3	4A	4B	4C	4ABC
Otomesostoma												1	1
Sphaerium striatinum	1			1	1		1	2		5	3		8
Stagnicola exilis		2	2	4	5	1	1	7	2	64	8	1	73
Physella gyrina													
Heliosoma anceps										1			1
Ferrissia rivularis													
Bdellodrillus illuminatus			1	1									
Pristina sp.					4	3		7	3			1	1
Limnodrilus hoffmeisteri													
Morreobdella fervida													
Oronectes sloanii													
Cambarus robustus	16	4	14	34	3	1	1	5	1	1	6	8	15
Ascellus sp.	1	1	3	5	1			1	1				
Gammarus pseudolimnaeus		1		1									
Ephemerella crenula						1		1					
Caenis sp.	4	7	4	15	4	5	1	10		1	2	1	4
Stenonema terminatum	24	20	4	48	44	26	45	115	6	14	20	7	41
Ephemera sp.		1	2	3									
Leptophlebia sp.		1		1	12	6	1	19	4	17	36	27	80
Calopteryx maculata													
Argia moesta													
Basiaeschna janata	1			1									
Arigomphus submedianus													
Pachydiplax longipennis													
Macromia illinoiensis													
Acroneuria carolinensis					3	1	2	6					
Ranatraa buenoi													
Nigronia serricornis	4	2	1	7	3	2	3	8		3	8	2	13
Corydalus cornutus													
Sialis sp.		1		1		1		1					
Helicopsyche borealis						1	1	2		1	1		2
Chimasrra atterrima					2	1		3					
Cheumatopsyche spp.											1		1
Haliplus sp.													
Berosus sp.													
Psephenus hetricki	8	5	1	14		2	1	3	1	9	13	6	28
Stenemis sexlineata						1		1			1		1
Helichus lithophilus		2		2		1		1		1	1		2
Ablabesmyia mallochi							1	1	1				
Chironomus sp.													
Endochironomus sp.	1	1		2	2		1	3	2	1			1
Tanytarsus sp.													
Cnephia sp.										1			1
Tipula sp.													
Chrysops sp.													
Nematelus sp.												1	1
Antichaeta sp.											1	1	2
Number of Taxa	9	13	9	16	12	15	12	19	9	13	13	11	19
Number of Organisms	60	48	32	140	84	53	59	196	21	119	101	56	276
EPT/Total Individuals	47%	60%	31%	48%	77%	77%	85%	80%	48%	28%	59%	63%	46%
Diversity H	2.08	2.42	2.13	2.62	2.12	2.21	1.23	2.15	2.26	2.07	2.54	2.2	2.59

Genus species	**5A**	**5B**	**5C**	**5ABC**	**6A**	**6B**	**6C**	**6ABC**	**7A**	**7B**	**7C**	**7ABC**	**8**
Otomesostoma													1
Sphaerium striatinum	1	5	1	7	1			1	1			1	
Stagnicola exilis	82	28	37	147	1			1					1
Physella gyrina	8	12	10	30					1			1	6
Heliosoma anceps													1
Ferrissia rivularis											1	1	1
Bdellodrillus illuminatus													
Pristina sp.	3	1	2	6		4	1	5	1	3		4	3
Limnodrilus hoffmeisteri													
Morreobdella fervida													
Oronectes sloanii													
Cambarus robustus	1	6	3	10	1		1	2			1	1	1
Ascellus sp.													
Gammarus pseudolimnaeus													
Ephemerella crenula													
Caenis sp.	7	9	6	22	1	2	2	5	5	4	3	12	2
Stenonema terminatum	20	35	25	80	3	4	5	12	11	7	2	20	47
Ephemera sp.		2	1	3									
Leptophlebia sp.	6	3	1	10	1	3		4			2	2	
Calopteryx maculata											1	1	2
Argia moesta		4		4									
Basiaeschna janata													
Arigomphus submedianus													1
Pachydiplax longipennis													
Macromia illinoiensis													
Acroneuria carolinensis													
Ranatraa buenoi													
Nigronia serricornis	1			1									
Corydalus cornutus			1	1	6	2	1	9					
Sialis sp.		1		1									3
Helicopsyche borealis		4		4	11	20		31	1			1	9
Chimasrra atterrima		1		1						3	2	5	6
Cheumatopsyche spp.		1		1	1			1	1	2	2	5	
Haliplus sp.													
Berosus sp.										1		1	
Psephenus hetricki	12	16	42	70			1	1	2	4	2	8	2
Stenemis sexlineata	2	2		4	3		1	4	1		1	2	
Helichus lithophilus					3			3	1			1	
Ablabesmyia mallochi													
Chironomus sp.													
Endochironomus sp.	1			1		10		10	3	7	7	17	2
Tanytarsus sp.		1	3	4	4	1	1	6	1			1	
Cnephia sp.													
Tipula sp.													
Chrysops sp.									4	1	1	6	
Nematelus sp.													
Antichaeta sp.										1		1	
Number of Taxa	12	17	12	20	12	8	8	15	13	10	12	20	16
Number of Organisms	144	131	132	407	36	46	13	95	33	33	25	91	88
EPT/Total Individuals	23%	42%	25%	30%	75%	63%	54%	65%	55%	48%	44%	49%	73%
Diversity H	2.2	3.07	2.57	2.9	2.55	2.02	1.95	2.86	2.53	2.53	2.59	3.12	2.84

Genus Species	**09**	**10A**	**10B**	**10C**	**10ABC**	**11A**	**11B**	**11C**	**11ABC**	**12A**	**12B**	**12C**	**12ABC**
Otomesostoma													
Sphaerium striatinum	1		2	3	5					1			1
Stagnicola exilis	1	17	13	34	64	4	10	11	25				
Physella gyrina	2		4	1	5	1		1	2		1	1	2
Heliosoma anceps			1		1	2	5	2	9			1	1
Ferrissia rivularis													
Bdellodrillus illuminatus													
Pristina sp.	5	4		1	5	17	14	7	38		5	3	8
Limnodrilus hoffmeisteri													
Morreobdella fervida		1	1		2								
Oronectes sloanii			3	2	5	13	9	14	36	12	10	6	28
Cambarus robustus		1		1	2								
Ascellus sp.													
Gammarus pseudolimnaeus							1		1	1			1
Ephemerella crenula													
Caenis sp.	1	7	1	3	11	13	21	20	54	4	11	5	20
Stenonema terminatum	1	17	29	17	63	29	54	92	175	16	14	16	46
Ephemera sp.													
Leptophlebia sp.		8		1	9							6	6
Calopteryx maculata													
Argia moesta			2	1	3								
Basiaeschna janata							1		1				
Arigomphus submedianus													
Pachydiplax longipennis	1					1			1				
Macromia illinoiensis													
Acroneuria carolinensis													
Ranatraa buenoi			1		1								
Nigronia serricornis			5	1	6							1	1
Corydalus cornutus													
Sialis sp.		1		1	2								
Helicopsyche borealis			1	2	3								
Chimasrra atterrima													
Cheumatopsyche spp.													
Haliplus sp.						1			1	1			1
Berosus sp.													
Psephenus hetricki		4	2	6	12	1	1	1	3	3	2	7	12
Stenemis sexlineata			1	1	2		1		1	1			1
Helichus lithophilus			1		1		1		1	1			1
Ablabesmyia mallochi												2	2
Chironomus sp.	4					1			1			1	1
Endochironomus sp.	1					1		1	2	1	1	3	5
Tanytarsus sp.	1	1		1	2								
Cnephia sp.													
Tipula sp.													
Chrysops sp.													
Nematelus sp.													
Antichaeta sp.			1		1								
Number of Taxa	10	10	16	16	21	12	11	9	16	10	7	12	17
Number of Organisms	18	61	68	76	205	84	118	149	351	41	44	52	137
ETT/Total Individuals	11%	52%	46%	30%	42%	50%	64%	75%	65%	49%	57%	52%	53%
Diversity H	2.28	2.58	2.49	2.57	3	2.37	2.21	1.73	2.23	1.91	1.67	2.35	2.1

Genus species	**13A**	**13B**	**13C**	**13ABC**	**14A**	**14B**	**14C**	**14ABC**	**15A**	**15B**	**15C**	**15ABC**
Otomesostoma											1	1
Sphaerium striatinum		2	3	5						1		1
Stagnicola exilis	5	12	48	65	30	33	48	111	34	23	23	80
Physella gyrina		1	2	3	4	1	5	10				
Heliosoma anceps			2	2	1			1				
Ferrissia rivularis												
Bdellodrillus illuminatus												
Pristina sp.			1	1					5	2	4	11
Limnodrilus hoffmeisteri												
Morreobdella fervida												
Oronectes sloanii	15	8	5	28					1	5	2	8
Cambarus robustus			1	1								
Ascellus sp.		1	1	2								
Gammarus pseudolimnaeus	1	2	1	4								
Ephemerella crenula											2	2
Caenis sp.	1	6	2	9	4			4	1	2	1	4
Stenonema terminatum	2	2	10	14	6	9	3	18	13	4	13	30
Ephemera sp.												
Leptophlebia sp.									31	7	8	46
Calopteryx maculata												
Argia moesta												
Basiaeschna janata												
Arigomphus submedianus												
Pachydiplax longipennis												
Macromia illinoiensis												
Acroneuria carolinensis							1	1				
Ranatraa buenoi												
Nigronia serricornis		1	2	3	1		3	4				
Corydalus cornutus							1	1				
Sialis sp.		2		2								
Helicopsyche borealis		1	1	2	1		12	13				
Chimasrra atterrima					8	9	16	33				
Cheumatopsyche spp.												
Haliplus sp.												
Berosus sp.												
Psephenus hetricki			5	5	1			1	18	10	19	47
Stenemis sexlineata										1		1
Helichus lithophilus												
Ablabesmyia mallochi												
Chironomus sp.			1	1								
Endochironomus sp.		1		1							2	2
Tanytarsus sp.					1			1				
Cnephia sp.					1			1				
Tipula sp.							1	1				
Chrysops sp.							1	1				
Nematelus sp.												
Antichaeta sp.					3	1	5	9				
Number of Taxa	5	12	15	17	12	5	11	16	7	9	10	12
Number of Organisms	24	39	85	148	61	53	96	210	103	55	75	233
EPT/Total Individuals	13%	23%	15%	16%	30%	34%	33%	33%	44%	24%	32%	31%
Diversity H	1.3	2.49	2.15	2.55	2.21	1.49	2.08	2.26	2.06	2.2	2.36	2.42

Genus species	**16A**	**16B**	**16C**	**16ABC**	**17A**	**17B**	**17C**	**17ABC**	**18A**	**18B**	**18C**	**18ABC**
Otomesostoma												
Sphaerium striatinum	1	1		2	1	2	1	4	2	2		4
Stagnicola exilis	2	3	5	10	4	5		9				
Physella gyrina		1	1	2								
Heliosoma anceps												
Ferrissia rivularis						1		1				
Bdellodrillus illuminatus												
Pristina sp.	1			1								
Limnodrilus hoffmeisteri		2	1	3	1	2	1	4		4		4
Morreobdella fervida												
Oronectes sloanii	2	4	2	8	5		1	6	1	2	1	4
Cambarus robustus					2			2				
Ascellus sp.												
Gammarus pseudolimnaeus												
Ephemerella crenula					2			2				
Caenis sp.	2	3	7	12	4	7	1	12	8	3	2	13
Stenonema terminatum	13	12	23	48	4	26	19	49	21	10	15	46
Ephemera sp.									1	5	1	7
Leptophlebia sp.		4	3	7		2		2	3			3
Calopteryx maculata												
Argia moesta					1			1				
Basiaeschna janata												
Arigomphus submedianus		1		1								
Pachydiplax longipennis												
Macromia illinoiensis							1	1	1			1
Acroneuria carolinensis					1	1		2				
Ranatraa buenoi												
Nigronia serricornis		3	2	5								
Corydalus cornutus					2			2	1		4	5
Sialis sp.		2	1	3	1			1				
Helicopsyche borealis												
Chimasrra atterrima									12	20	11	43
Cheumatopsyche spp.									4	2		6
Haliplus sp.												
Berosus sp.												
Psephenus hetricki	27	14	9	50	5			5			2	2
Stenemis sexlineata			1	1	4			4				
Helichus lithophilus										1		1
Ablabesmyia mallochi									2			2
Chironomus sp.						1		1	1			1
Endochironomus sp.	1	3	2	6	1	2	2	5	7	5	3	15
Tanytarsus sp.												
Cnephia sp.												
Tipula sp.						1		1		3		3
Chrysops sp.		1		1								
Nematelus sp.												
Antichaeta sp.												
Number of Taxa	8	14	12	16	15	11	7	20	13	11	8	17
Number of Organisms	49	54	57	160	38	50	26	114	64	57	39	160
EPT/Total Individuals	31%	39%	60%	44%	29%	72%	77%	56%	77%	53%	74%	74%
Diversity H	1.64	2.8	2.41	2.67	3.01	2.07	1.06	2.79	2.53	2.55	2.04	3.72

- There were exceedances of the sediment benchmark of 0.190 µg/g for RDX at sampling locations 02 (0.280 µg/g), 04 (0.190 µg/g), 06 (0.260 µg/g), 07 (0.420 µg/g), 08 (1.90 µg/g), 10 (0.220 µg/g), 11 (0.350 µg/g), 12 (0.280 µg/g), 13 (0.300 µg/g), 14 (0.220 µg/g), 16 (1.100 µg/g), and 17 (0.260 µg/g). Sampling locations 07, 08, 09, 10, 11, and 12 were all upstream reference locations and should not be contaminated with explosives. Also, the RDX sediment benchmark was calculated from a series of freshwater toxicity tests and was very conservative. The lowest acute toxicity value for RDX in water was 3.6 mg/L and the maximum chronic to acute ratio was 0.52 making a chronic value 1.8 mg/L without being conservative (Bentley, 1977). Therefore, if all of the RDX in the sediment was available to the benthic organisms as if it were in the water with none tied up by carbon, only sampling location 08 with 1.9 mg/kg RDX would be close to possibly causing an adverse effect on the biota. Since there was no discernible adverse impact on any of the sampling location macroinvertebrates, none of the exceedances had an impact.
- Next, the data were evaluated by comparing the results from downstream locations to reference locations. This would determine if the firing and impact area activities were contributing munitions-related compounds to the watershed. Last, the ecological health of the benthic macroinvertebrate populations were evaluated to determine if firing and impact area activities were adversely impacting the aquatic biota. There were two watersheds (Middle Fork Creek and Marble Creek) that originated on JPG. To have a reference for comparison the reference results from the other watersheds were averaged. The results are presented below.

8.4.1 Collective Upstream Reference Sampling Locations

Sampling locations 07-12 were all upstream locations on the north and east boundary of JPG. Explosives are not naturally occurring compounds. Therefore, there should be no detectable levels of explosives in any of the reference sampling locations. Metals on the other hand are naturally occurring elements. The metals concentrations found at the reference locations should not be influenced by JPG activities and should represent background (environmental) levels for the JPG area. The reference locations were used for comparison to downstream locations that may have been influenced by upstream firing and impact area activities. Because Middle Fork Creek and Marble Creek originated on JPG, the reference surface water and sediment data were averaged for use in comparing to downstream locations. The benthic macroinvertebrate populations at the reference locations were used for comparison to downstream locations where explosive-related compounds could have adversely impacted the health of the aquatic biota. The reference locations were used within the same watershed when possible but an average of the six reference locations was also used, and where there were no or poor reference data for the watershed only the reference average was used (e.g., Middle Fork Creek and Marble Creek).

8.4.1.1 <u>Surface Water Results</u>

Surface water results and the average for the six reference locations are presented in Table 8-8.

TABLE 8-8 SURFACE WATER RESULTS AND AVERAGE FOR REFERENCE LOCATIONS

PARAMETER	UNIT	SW-07	SW-08	SW-09	SW-10	SW-11	SW-12	Reference Average (SW7-SW12)
Explosives and Degradates								
HMX	µg/L	3.0 U	3.0 U	3.0 U	3.0 U	3.0 U	3.0 U	3.0
RDX	µg/L	0.100 U	0.100 U	**0.023 J**	**0.072 J**	**0.036 J**	**0.040 J**	0.062
2,4,6-TNT	µg/L	0.030 U	0.030 U	0.030 U	0.030 U	0.030 U	0.030 U	0.03
1,3-DNB	µg/L	0.090 U	0.090 U	0.090 U	0.090 U	0.090 U	0.090 U	0.09
1,3,5-TNB	µg/L	0.030 U	0.030 U	0.030 U	0.030 U	0.030 U	0.030 U	0.03
TETRYL	µg/L	0.50 U	0.50 U	0.50 U	0.50 U	0.50 U	0.50 U	0.5
NB	µg/L	0.030 U	0.030 U	0.030 U	0.030 U	0.030 U	0.030 U	0.03
2A-4,6-DNT	µg/L	0.10 U	0.10 U	0.10 U	0.10 U	0.10 U	0.10 U	0.1
4A-2,6-DNT	µg/L	0.10 U	0.10 U	0.10 U	0.10 U	0.10 U	0.10 U	0.1
2,6-DNT	µg/L	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.01
2,4-DNT	µg/L	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.02
2-NT	µg/L	0.090 U	0.090 U	0.090 U	0.090 U	0.090 U	0.090 U	0.09
3-NT	µg/L	0.090 U	0.090 U	0.090 U	0.090 U	0.090 U	0.090 U	0.09
4-NT	µg/L	0.090 U	0.090 U	0.090 U	0.090 U	0.090 U	0.090 U	0.09
Nitroglycerin	µg/L	0.090 U	0.090 U	0.090 U	0.090 U	0.090 U	0.090 U	0.09
WP	µg/L	0.024 U	0.024 U	0.024 U	0.024 U	0.024 U	0.024 U	0.024
Metals								
Hardness	mg/L	172	208	156	160	116	148	160
Antimony (Total/*Dissolved*)	µg/L	**0.0924** ***0.0913***	**0.0734** ***0.0651***	**0.0957** ***0.0886***	**0.1230** ***0.1110***	**0.1510** ***0.1580***	**0.0861** ***0.0844***	0.1036 0.0997
Arsenic	µg/L	**1.160** ***1.290***	**0.808** ***0.896***	**0.917** ***1.150***	**1.180** ***1.090***	**1.050** ***0.997***	**0.785** ***0.738***	0.983 1.027
Barium	µg/L	**52.9** ***51.2***	**58.2** ***57.3***	**65.3** ***62.6***	**58.4** ***58.1***	**56.5** ***54.9***	**55.2** ***53.7***	57.8 56.3
Cadmium	µg/L	**0.00963** ***0.01040***	**0.06130** ***0.02530***	**0.13600** ***0.01880***	**0.01700** ***0.08690***	**0.01980** ***0.02210***	**0.01740** ***0.01610***	0.04352 0.02993
Calcium	µg/L	**51900** ***51800***	**57100** ***57100***	**44800** ***44300***	**53400** ***45600***	**33300** ***33300***	**43900** ***43600***	47400 45950
Chromium	µg/L	**0.4080** ***0.3940***	**0.5220** ***0.8110***	**0.2920** ***0.4030***	**0.2980** ***0.3160***	**0.7540** ***0.1250***	**0.3390** ***0.2900***	0.4355 0.3898
Copper	µg/L	**0.989** ***0.968***	**0.614** ***0.600***	**1.180** ***1.180***	**1.120** ***1.030***	**1.370** ***1.260***	**1.120** ***1.140***	1.066 1.030
Lead	µg/L	**0.05780** ***0.01890***	**0.07110** ***0.00830***	**0.04080** *0.00500 U*	**0.07490** ***0.01300***	**2.01000** ***0.03410***	**0.23500** ***0.22500***	0.41493 0.05072
Magnesium	µg/L	**10300** ***10300***	**16400** ***15800***	**11200** ***11000***	**13500** ***11400***	**8050** ***8100***	**9560** ***9550***	11502 11025
Manganese	µg/L	**27.70** ***11.40***	**50.10** ***39.70***	**78.80** ***22.70***	**56.60** ***55.50***	**89.20** ***72.70***	**37.10** ***34.90***	56.58 39.48
Mercury	µg/L	**0.001700** ***0.001330***	**0.000890** ***0.000860***	**0.002280** ***0.002020***	**0.001820** ***0.001350***	**0.001870** ***0.001330***	**0.002140** ***0.002160***	0.001783 0.001508
Molybdenum	µg/L	**0.928** ***0.861***	**1.070** ***1.020***	**1.650** ***1.380***	**1.330** ***1.310***	**0.858** ***0.845***	**0.493** ***0.565***	1.055 0.997
Nickel	µg/L	**2.23** ***2.48***	**2.43** ***2.44***	**2.33** ***2.35***	**2.42** ***2.52***	**1.75** ***1.67***	**2.01** ***2.28***	2.20 2.29
Silver	µg/L	**0.01220 B** *0.00400 U*	**0.04300 B** ***0.00401 B***	**0.01860 B** *0.00400 U*	**0.01010 B** ***0.00685 B***	**0.22000** ***0.25800***	**0.00858 B** ***0.00841B***	0.05208 0.04755
Uranium	µg/L	**0.510** ***0.483***	**0.796** ***0.779***	**1.110** ***1.040***	**0.580** ***0.575***	**0.665** ***0.650***	**0.640** ***0.653***	0.717 0.697
Vanadium	µg/L	**0.707** ***0.632***	**0.562** ***0.485***	**0.629** ***0.567***	**0.739** ***0.622***	**1.430** ***0.983***	**0.784** ***0.688***	0.809 0.663
Zinc	µg/L	**1.180** ***0.702***	**2.180** ***1.210***	**1.870** ***1.020***	**1.010** ***4.410***	**1.740** ***0.484***	**1.460** ***1.660***	1.573 1.581
Other Parameters								
Perchlorate	µg/L	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0
TOC	mg/L	6.5	3.2	8.3	7.0	6.1	5.6	6.1
pH (Field, Lab)	s.u.	8.17	7.55	7.15	7.69	7.69	8.22	NA
D.O. (Field)	mg/L	11.24	10.51	7.37	8.14	8.4	13.21	NA
Conductivity (Field)	µ-ohm	319	369	271	407	407	290	NA
Temperature (Field)	Deg.Cel.	16.55	15.68	15.38	14.2	14.2	14.39	NA

Bold-represents results above detection limit. **B**-represents parameter was also detected in laboratory blank for that run. **J**-estimate value below reporting limit. **NA**-not available. **U**-under detection limit.

8.4.1.1.1 Metals and Hardness

Table 8-8 presents the hardness and metals reference data and the average. Since no military activity was known to have occured above the reference locations, the concentrations were initially assumed to represent reference metals levels for surface water in the area around JPG. The presence of some munitions constituents in the sediment samples suggests the possibility that military activity may in fact have occurred upstream of these locations. Metals that were not detected above the detection limit (flagged by a “U”) were assumed to contain the detection limit concentration for that metal in the average. The hardness averaged 160 mg/L. This value is fairly high because of the limestone in the area. The harder the water the less toxic metals are to aquatic life.

8.4.1.1.2 Explosives and Degradates

No explosives were detected above the reporting limit in any of the reference surface water samples.

8.4.1.1.3 Perchlorate, Total Organic Carbon (TOC), and Field Parameters

Table 8-8 presents the perchlorate, TOC, and field parameters. Perchlorate was not detected, TOC averaged 6.1, and the field parameters were well within the range to support a healthy aquatic ecosystem.

8.4.1.1.4 Water Quality Criteria Screening

The Federal WQC and State WQS for metals are presented in Table 8-3 and 8-5. They are based on hardness of the water. The Federal WQC are based on dissolved metals and the State WQS are based on total metals. The harder the water the less toxic metals are to aquatic organisms. Even though the average hardness of the reference locations was 160 mg/L, 100 mg/L hardness was used in calculating WQC to be conservative because one of the sampling locations (17) had 98 mg/L hardness. All metals were within WQC and WQSs. However, manganese exceeded a secondary drinking water standard of 50 µg/L at sampling locations 10 (55.5 µg/L) and 11 (72.7 µg/L) indicating that the natural background in this limestone area can be above the standard. The lowest observed affect concentration for aquatic toxicity for manganese was 1,775 µg/L Kimball (nd). The tier II secondary chronic value was calculated to be 120 µg/L manganese (Jones, et. al 1997).

8.4.1.2 Sediment Results

Sediment results for all samples, along with the applicable SQBs, are presented in Table 8-6. The results of the reference locations and the reference averages are presented in Table 8-9. The analytical reference results are discussed below.

TABLE 8-9. SEDIMENT RESULTS FOR REFERENCE LOCATIONS, JPG FIRING RANGE STUDY, 7-11 OCTOBER 2002

PARAMETER	UNIT	SE-07	SE-08	SE-09	SE-10	SE-11	SE-12	Reference Average (SE-07-12)
Explosives and Degradates								
HMX	µg/g	**0.091**	**0.260**	0.050 U	0.050 U	0.050 U	0.050 U	0.092
RDX	µg/g	**0.420**	**1.900**	**0.098**	**0.220**	**0.350**	**0.280**	0.545
2,4,6-TNT	µg/g	**0.086**	**0.280**	**0.200**	**0.034**	**0.054**	**0.047**	0.117
1,3-DNB	µg/g	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020
1,3,5-TNB	µg/g	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020
TETRYL	µg/g	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020
NB	µg/g	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020
2A-4,6-DNT	µg/g	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020
4A-2,6-DNT	µg/g	0.050 U	0.050 U	0.050 U	0.050 U	0.050 U	0.050 U	0.050
2,6-DNT	µg/g	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010
2,4-DNT	µg/g	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020
2-NT	µg/g	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020
3-NT	µg/g	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020
4-NT	µg/g	0.070 U	0.070 U	0.050 U	0.060 U	0.070 U	0.060 U	0.063
Nitroglycerin	µg/g	0.050 U	0.050 U	0.050 U	0.050 U	0.050 U	0.050 U	0.050
WP	µg/g	0.0010 U	0.0010 U	0.0010 U	0.0010 U	0.0010 U	0.0010 U	0.001
Moisture (WP only)	Percent	**21**	**11**	**18**	**22**	**20**	**22**	19
Metals								
Antimony	µg/g	**0.271**	**0.348**	**0.195**	**0.141**	**0.196**	**0.31**	0.244
Arsenic	µg/g	**3.79 B**	**6.45**	**3.70 B**	**7.68**	**3.40 B**	**9.64**	5.78
Barium	µg/g	**246**	**180**	**243**	**261**	**159**	**149**	206
Cadmium	µg/g	**0.103 B**	**0.0955 B**	**0.0964 B**	**0.0822 B**	**0.0823 B**	**0.108 B**	0.0946
Chromium	µg/g	**17.50**	**11.90**	**7.53**	**9.40**	**8.61**	**12.70**	11.27
Copper	µg/g	**3.07**	**4.61**	**3.85**	**8.20**	**2.28**	**3.07**	4.18
Lead	µg/g	**6.84**	**11.50**	**7.03**	**7.85**	**4.80**	**9.04**	7.84
Manganese	µg/g	**154**	**496**	**237**	**235**	**143**	**327**	265
Mercury	µg/g	**0.01350 B**	**0.01600 B**	**0.01910 B**	**0.01020**	**0.01380**	**0.01380**	0.01440
Molybdenum	µg/g	**0.837**	**1.150**	**0.452**	**0.486**	**0.642**	**0.881**	0.741
Nickel	µg/g	**5.24**	**6.61**	**3.08**	**4.06**	**2.42**	**3.69**	4.18
Silver	µg/g	**0.0729**	**0.1350**	**0.0485**	**0.1060**	**0.1460**	**0.1020**	0.1017
Uranium	µg/g	**0.357**	**0.948**	**0.682**	**0.436**	**0.416**	**0.531**	0.562
Vanadium	µg/g	**21.7**	**25.5**	**16.1**	**13.9**	**27.3**	**27.6**	22.0
Zinc	µg/g	**16.7**	**23.8**	**19.2**	**16.0**	**15.6**	**21.7**	18.8
Moisture	Percent	**20.7**	**12.0**	**20.8**	**20.7**	**17.1**	**20.2**	18.6
Other Parameters								
Total Organic Matter	Percent	**0.6**	**1.6**	**0.6**	**0.6**	**0.7**	**0.8**	0.8
Perchlorate	µg/g	0.013 U	0.011 U	0.013 U	0.013 U	0.013 U	0.013 U	0.013
Benthic Macroinvertebrate Summa								
Number of Taxa		20	16	10	21	16	17	17
Number of Individuals		91	88	18	205	351	134	148
EPT/Total Individuals		49%	73%	11%	41%	65%	53%	49%
Diversity H		3.12	2.84	2.28	3.00	2.23	2.31	2.63

Bold-represents results above detection limit. **B**-represents parameter was also detected in laboratory blank for that run. **J**-estimate value below reporting limit. **NA**-not available.
U-under detection limit.

Highlighted represents exceedance of SQB

8.4.1.2.1 Metals

Table 8-9 presents sediment results and average metals concentrations of the reference locations. These results represent the background sediment concentrations for the JPG area. As with the surface water data, metals that were not detected above the reporting limit were assumed to contain the reporting limit concentration for calculating the average. These average sediment metals concentrations represent the background level for the JPG drainage basins without their own reference site.

8.4.1.2.2 Explosives and Degradates

The explosive HMX was detected at sampling locations 07 (0.091 µg/g) and 08 (0.260 µg/g), RDX was detected at all six reference locations, and 2, 4, 6-TNT was detected at all six reference locations. The remainder of the explosives were not detected at any of the reference locations. The explosive HMX, RDX, and 2,4,6-TNT averaged 0.92, 0.545, and 0.117 µg/g, respectively. Since explosives would not be expected at the reference locations, the data has a degree of uncertainty attached to it. Possible reasons for the explosives being found in the reference locations include false positive detections, cross contamination, interference in the analytical method, or contamination offpost caused by stray shots or aerial deposition (smoke or unburned residue blowing in the wind). The data has been third party validated and explosives laboratory data passed the evaluation with the qualifiers. The detected explosives at reference locations are most likely due to undocumented military activity in the area.

8.4.1.2.3 Perchlorate and Total Organic Matter

There was no perchlorate detected at any of the reference locations and the total organic matter averaged 0.8 percent.

8.4.1.2.4 Sediment Quality Benchmarks

The results for the reference locations are presented in Table 8-9. The SQBs are presented and the exceedances are highlighted in Table 8-6. The RDX SQB of 0.19 µg/g was exceeded at sampling locations 07 (0.42 µg/g), 08 (1.90 µg/g), 10 (0.22 µg/g), 11 (0.35 µg/g), 12 (0.28 µg/g), and the reference average (0.545 µg/g). The arsenic SQB of 5.9 µg/g was exceeded at sampling locations 08 (6.45 µg/g), 10 (7.68 µg/g), and 12 (9.64 µg/g). The manganese SQB of 460 µg/g was exceeded at sampling location 08 (496 µg/g). The reference average was 265 µg/g manganese. These results indicate that reference locations exceeded SQBs for some constituents.

8.4.1.3 Benthic Macroinvertebrate Results

Benthic macroinvertebrate results for all sampling locations are presented in Table 8-7 and summarized for reference locations in Table 8-9. All of the JPG sampling locations to include the reference locations had a limited benthic macroinvertebrate population. The drought, the moderately high water caused by 6-7 inches of rain during the 27 September storm event, and the limited substrate made for a rather sparse benthic macroinvertebrate population. However, the reference locations had a good mix of pollution intolerant species with an average diversity of 2.63, 17 taxa, and 148 individuals per sample location. Diversity (H) values represent stream ecology as follows: above 3.0 – high quality, between 1.0 and 3.0 – intermediate quality, and below 1.0 – poor quality.

8.4.1.4 Collective Upstream Reference Sampling Locations Summary

Average reference conclusions are based on the one sampling event data collected during the field investigation. The data collected do not account for temporal variations and represent point estimates of exposure. The surface water results did not exceed WQC but some varied considerable from each other. Some of the sediment results for the reference locations exceeded SQBs for RDX, arsenic, and manganese. These exceedances indicate that reference locations can be high for some metals. The explosives detected at the reference locations suggest a potential problem at JPG that needs to be investigated further. However, these exceedances were not significant enough to adversely impact human health or the aquatic biota.

8.4.2 Middle Fork Creek Sampling Locations

See Figure 8-1 for sampling locations and watershed location in relation to firing line and impact fields. Middle Fork Creek drains the area of the firing line out to about 3000 meters near the western boundary and to 5500 meters near the eastern boundary. The stream starts close to the eastern boundary and drains southwest, draining several impact fields and the southeast corner of the Depleted Uranium Impact Area. There were two sampling locations (01 and 13) on Middle Fork Creek. Sampling location 01 was near the western perimeter road and sampling location 13 was near Morgan Road slightly more than midway through the installation. Since Middle Fork Creek originates on the installation, the average of the six reference locations from the other watersheds was used for background comparisons. When discussing the comparison between sampling locations and JPG reference locations, the term substantial was used if the sampling location value exceeded all of the six reference values.

8.4.2.1 Surface Water Results

Analytical results for all JPG surface water samples are presented in Table 8-5. The Federal WQC and State WQSs applicable to JPG surface waters are included in Table 8-5 for easy comparison. Middle Fork Creek surface water analytical results are presented in Table 8-10 and discussed below.

8.4.2.1.1 Metals and Hardness

There were more metals results lower than the average reference values than were higher at SW-01 and SW-13. The only metal at SW-01 that was substantially higher than the reference locations was dissolved cadmium (0.344 µg/L compared to 0.0299 µg/L). However, total cadmium was only 0.0661 µg/L at SW-01 and dissolved cadmium would not exceed total cadmium. Therefore, the increase is questionable. Sampling location SW-13, upstream of SW-01, had several total metals substantially higher than reference locations (barium, calcium,

TABLE 8-10 MIDDLE FORK CREEK SURFACE WATER RESULTS

PARAMETER	UNIT	SW-1	SW-13	Reference Average (SW7-SW12)	REGULATORY CRITERIA*			
					FEDERAL AMBIENT WATER QUALITY CRITERIA		INDIANA AMBIENT WATER QUALITY CRITERIA	
					CMC	CCC	CMC	CCC
Explosives and Degradates								
HMX	µg/L	3.0 U	3.0 U	3.0	NA	330	No numeric criteria have been established for these compounds.	
RDX	µg/L	**0.190**	**0.025 J**	0.062	4000	190		
2,4,6-TNT	µg/L	0.030 U	0.030 U	0.03	570	130		
1,3-DNB	µg/L	0.090 U	0.090 U	0.09	110	30		
1,3,5-TNB	µg/L	0.030 U	0.030 U	0.03	30	14		
TETRYL	µg/L	0.50 U	0.50 U	0.5	NA	NA		
NB	µg/L	0.030 U	0.030 U	0.03	27,000			
2A-4,6-DNT	µg/L	0.10 U	0.10 U	0.1	NA	NA		
4A-2,6-DNT	µg/L	0.10 U	0.10 U	0.1	NA	NA		
2,6-DNT	µg/L	0.010 U	0.010 U	0.01	18,500	NA		
2,4-DNT	µg/L	0.020 U	0.020 U	0.02	330	230		
2-NT	µg/L	0.090 U	0.090 U	0.09	NA	NA		
3-NT	µg/L	0.090 U	0.090 U	0.09	NA	NA		
4-NT	µg/L	0.090 U	0.090 U	0.09	NA	NA		
Nitroglycerin	µg/L	0.090 U	0.090 U	0.09	1700	200		
WP	µg/L	0.024 U	0.024 U	0.024	0.5	0.1		
Metals								
Hardness	mg/L	141	116	160	-	-	-	-
Antimony (Total/*Dissolved*)	µg/L	**0.0877** ***0.0992***	**0.0937** ***0.0644***	0.1036 0.0997	- 180	- 30	-	-
Arsenic	µg/L	**0.420** ***0.436***	**0.572** ***0.329***	0.983 1.027	- 340	- 150	360 -	190 -
Barium	µg/L	**66.6** ***66.4***	**122.0** ***49.0***	57.8 56.3	- 1000	1000	- -	- -
Cadmium	µg/L	**0.06610** ***0.34400***	**0.10100** ***0.01080***	0.04352 0.02993	- 4.3	- 2.2	4 -	1.1 -
Calcium	µg/L	**35500** ***35800***	**92900** ***27300***	47400 45950	- -	- -	- -	- -
Chromium	µg/L	**0.3580** ***0.3020***	**0.0309** *0.0240 U*	0.4355 0.3898	- 570	- 74	1737 -	207 -
Copper	µg/L	**1.240** ***1.260***	**5.520** ***0.657***	1.066 1.030	- 13	- 9	18 -	9 -
Lead	µg/L	**0.03100** *0.00500 U*	**0.09770** *0.00500 U*	0.41493 0.05072	- 65	- 2.5	82 -	3 -
Magnesium	µg/L	**12600** ***12600***	**13100** ***11600***	11502 11025	- -	- -	- -	- -
Manganese	µg/L	**5.28** ***2.84***	**251.00** ***4.65***	56.58 39.48	- 50	- -	- -	- -
Mercury	µg/L	**0.001050** ***0.000958***	**0.00174** ***0.00110***	0.001783 0.001508	- 1.4	- 0.77	2.4 -	0.012 -
Molybdenum	µg/L	**0.673** ***0.695***	**0.218** ***0.260***	1.055 0.997	- 16000	- 370	- -	- -
Nickel	µg/L	**1.48** ***1.45***	**3.70** ***1.14***	2.20 2.29	- 470	- 52	1418 -	158 -
Silver	µg/L	**0.02710 B** ***0.04800 B***	**0.04670 B** ***0.02390 B***	0.05208 0.04755	- 3.4	- -	2 -	- -
Uranium	µg/L	**0.636** ***0.654***	**0.353** ***0.368***	0.717 0.697	- 46	- 2.6	- -	- -
Vanadium	µg/L	**0.263** ***0.233***	**0.326** ***0.132***	0.809 0.663	- 280	- 20	- -	- -
Zinc	µg/L	**0.487** ***0.480***	**12.500** ***0.393***	1.573 1.581	- 120	- 120	117 -	106 -
Other Parameters								
Perchlorate	µg/L	1.0 U	1.0 U	1.0	5000	600	-	-
TOC	mg/L	3.7	**3.2**	6.1	-	-	-	-
pH (Field, Lab)	s.u.	7.5	7.7		6.5 - 9.0		-	
D.O. (Field)	mg/L	6.5	8.9		-	-	-	-
Conductivity (Field)	µohm	238	203		-	-	-	-
Temperature (Field)	Deg.Cel.	11.02	12.37		-	-	-	-

*-For complete citations see Table 8-3. Underlining-represents results substantially above reference (above all reference values). **Bold**-represents results above detection limit. **B**-represents parameter was also detected in laboratory blank for that run. **J**-estimate value below reporting limit. **NA**-not available. **U**-under detection limit.

copper, manganese, nickel, and zinc). Since none of the dissolved metals were any higher at SW-13 than the reference locations, there is a strong possibility that extra suspended solids somehow got into the total metals sample. Whether the solids were stirred up by the sampling effort or something happening upstream cannot be determined. Also, SW-01 that was downstream of SW-13 did not show similar results even though the SW-01 sample was collected about 2 hours earlier.

8.4.2.1.2 Explosives and Degradates

The explosive RDX was detected at SW-01 (0.19µg/L) and detected below the reporting limit at SW-13. However, RDX was also detected below the reporting limit at four of the six reference locations. No other explosives were detected in the surface water of Middle Fork Creek. The concentration detected at SW-01 is only 1/100 the level that is considered safe for aquatic life.

8.4.2.1.3 Perchlorate and Field Parameters

Perchlorate was not detected in the surface water of Middle Fork Creek. TOC and the field parameters were well within reference values and what would be required to support a healthy ecological community.

8.4.2.1.4 Water Quality Criteria Screening

There were no exceedances of Federal WQC or State WQSs in Middle Fork Creek.

8.4.2.2 <u>Sediment Results</u>

The Middle Fork Creek sediment sampling results along with the SQBs are presented in Table 8-11. The results are discussed below.

8.4.2.2.1 Metals

Metals were generally higher in the sediments of SE-01 and SE-13 than in the sediments of the reference locations. The metals that were substantially higher at both Middle Fork Creek sampling locations than at the reference locations were antimony, cadmium, chromium, lead, manganese, and zinc. Arsenic and vanadium were both substantially higher than the reference locations at SE-01 only. The significance of these metals being higher than the reference is not understood since only arsenic, barium, and manganese exceed SQBs. These three metals would not be considered major components of explosives. Also, of the metals substantially higher in the sediment, only cadmium, manganese, and zinc were correspondingly higher in the water samples, and cadmium was questionable because the dissolved far exceeded total in the water sample. The benthic macroinvertebrates showed no adverse impact.

TABLE 8-11 MIDDLE FORK CREEK SEDIMENT RESULTS

PARAMETER	UNIT	SE-01	SE-13	Reference Average (SE-7-SE-12)	REGULATORY CRITERIA* SEDIMENT QUALITY BENCHMARK
Explosives and Degradates					
HMX	µg/g	0.050 U	**0.140**	0.092	0.330[1]
RDX	µg/g	**0.031**	**0.300**	0.545	0.190[1]
2,4,6-TNT	µg/g	0.010 U	**0.050**	0.117	0.52[1]
1,3-DNB	µg/g	0.020 U	0.020 U	0.020	0.04[1]
1,3,5-TNB	µg/g	0.020 U	0.020 U	0.020	0.02[1]
TETRYL	µg/g	0.020 U	0.020 U	0.020	NA
NB	µg/g	0.020 U	0.020 U	0.020	27.0[1]
2A-4,6-DNT	µg/g	0.020 U	0.020 U	0.020	NA
4A-2,6-DNT	µg/g	0.050 U	0.050 U	0.050	NA
2,6-DNT	µg/g	0.010 U	0.010 U	0.010	18.5[1]
2,4-DNT	µg/g	0.020 U	0.020 U	0.020	0.230[1]
2-NT	µg/g	0.020 U	0.020 U	0.020	NA
3-NT	µg/g	0.020 U	0.020 U	0.020	NA
4-NT	µg/g	0.040 U	0.070 U	0.063	NA
Nitroglycerin	µg/g	0.050 U	0.050 U	0.050	NA
WP	µg/g	0.0010 U	0.0010 U	0.001	0.26[5]
Moisture (WP only)	Percent	20	20	19	NA
Metals					
Antimony	µg/g	**<u>0.407</u>**	**<u>0.474</u>**	0.244	NA
Arsenic	µg/g	**<u>13.10</u>**	**<u>8.82</u>**	5.78	5.9[2]
Barium	µg/g	**189**	**210**	206	500[3]
Cadmium	µg/g	**<u>0.219 B</u>**	**<u>0.1780 B</u>**	0.0946	0.596[2]
Chromium	µg/g	**<u>31.20</u>**	**<u>23.5</u>**	11.27	26[3]
Copper	µg/g	**5.20**	**9.65**	4.18	16[3]
Lead	µg/g	**<u>15.10</u>**	**<u>19.40</u>**	7.84	31[3]
Manganese	µg/g	**<u>500</u>**	**<u>743</u>**	265	460[3]
Mercury	µg/g	**0.00630 J**	**0.00990 J**	0.01440	0.174[2]
Molybdenum	µg/g	**1.330**	**1.120**	0.741	NA
Nickel	µg/g	**5.26**	**6.19**	4.18	16[3]
Silver	µg/g	**0.1350**	**0.0660**	0.1017	1[4]
Uranium	µg/g	**0.599**	**0.629**	0.562	NA
Vanadium	µg/g	**<u>37.0</u>**	**25.2**	22.0	NA
Zinc	µg/g	**<u>33.2</u>**	**<u>51.6</u>**	18.8	120[3]
Moisture	Percent	**19.9**	**22.8**	18.6	NA
Other Parameters					
Total Organic Matter	Percent	**1.1**	**0.9**	0.8	NA
Perchlorate	µg/g	0.013 U	0.013 U	0.013	NA
Benthic Macroinvertebrate Summary					
Number of Taxa		16	17	17	
Number of Individuals		140	148	148	
EPT/Total Individuals		48%	17%	49%	
Diversity H		2.62	2.55	2.63	

*-For complete citations see Table 8-3. <u>Underlining</u>-represents results substantially above reference (above all reference values). **Bold**-represents results above detection limit. **B**-represents parameter was also detected in laboratory blank for that run. **J**-estimate value below reporting limit. **NA**-not available. **U**-under detection limit.

Highlighted represents exceedance of SQB

8.4.2.2.2 Explosives and Degradates

Three of the explosives were detected in the sediment samples of Middle Fork Creek and the reference locations. None of the explosives in the sediment were substantially higher in Middle Fork Creek than they were in the reference locations. The furthest downstream location (01) had only RDX detected at 0.031 µg/g in the sediment. However, sample SE-13 (mid-installation sample) had 0.14 µg/g HMX, 0.300 µg/g RDX and 0.050 µg/g 2,4,6-TNT. The average reference values were 0.092 µg/g HMX, 0.545 µg/g RDX, and 0.117 µg/g 2,4,6-TNT.

8.4.2.2.3 Perchlorate

Perchlorate was not detected in Middle Fork Creek Sediments.

8.4.2.2.4 Sediment Quality Benchmarks

The sediment results and SQBs for Middle Fork Creek are presented in Table 8-11. The explosive RDX in sediment sample SE-13 with 0.300 µg/g RDX exceeded the very conservative benchmark of 0.190 µg/g for RDX. However, the average reference location concentration of 0.545 µg/g RDX in the sediment exceeded the SQB even more. There were three metals that exceeded SQBs in Middle Fork Creek sediments: arsenic SQB of 5.9 µg/g at SE-01 with 13.1 µg/g arsenic and SE-13 with 8.82µg/g arsenic, chromium SQB of 26 µg/g at SE-1 with 31.2 µg/g chromium, and manganese SQB of 460 µg/g at SE-1 with 500 µg/g manganese and SE-13 with 743 µg/g manganese. The conservative SQBs were only slightly exceeded, and chemistry data alone can only indicate that there is a possibility of an adverse impact on the ecological health. Benthic macroinvertebrate data were used to make the final determination.

8.4.2.3 Benthic Macroinvertebrate Results

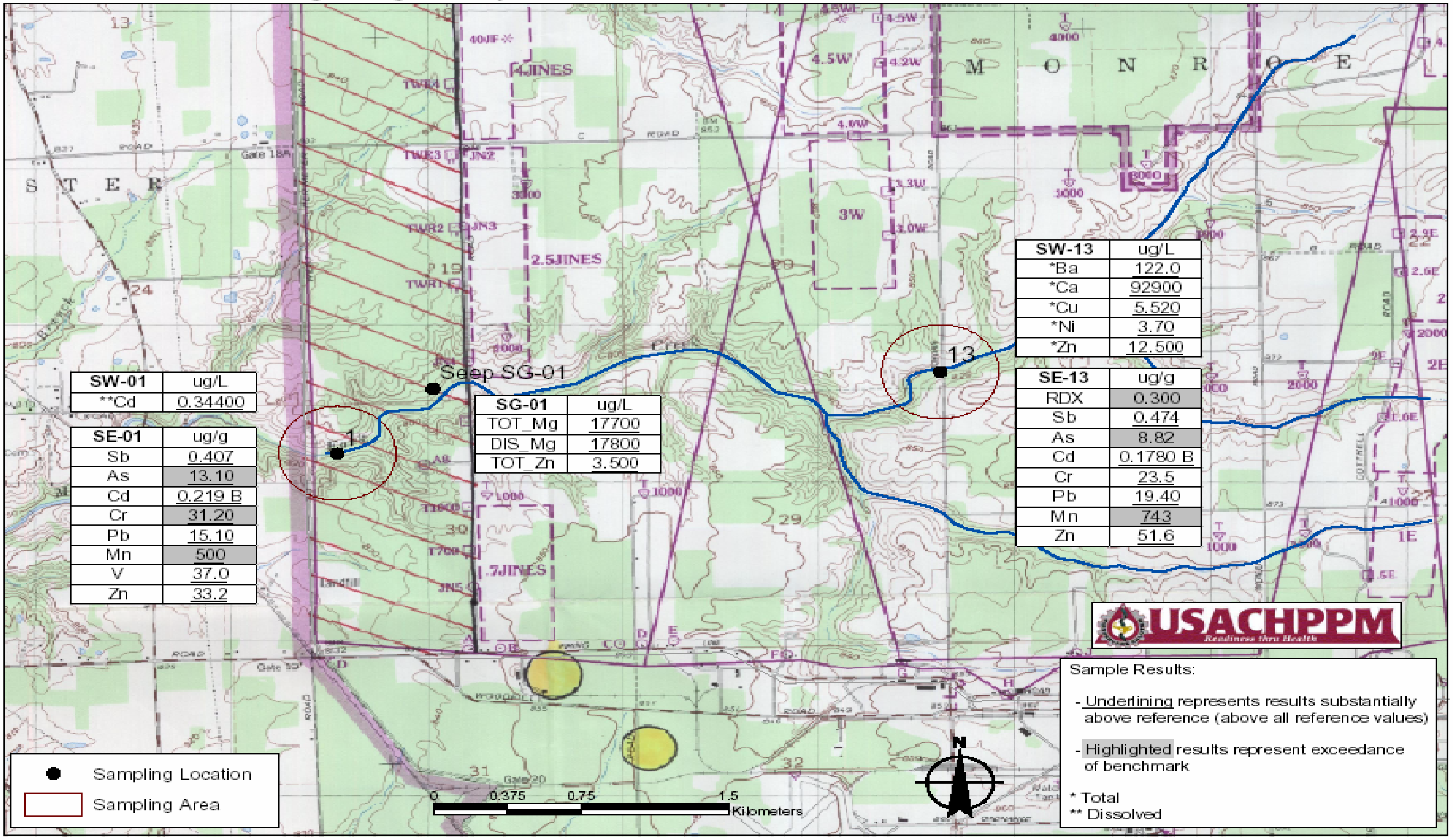
The benthic macroinvertebrate results for all samples are presented in Table 8-7 and results for Middle Fork Creek are summarized in Table 8-11. There were no discernable differences in the benthic macroinvertebrate population in Middle Fork Creek compared to the reference locations. There was no sign of adverse impact on the benthic macroinvertebrate population in Middle Fork Creek.

8.4.2.4 Middle Fork Creek Summary

Figure 8-2 shows the Middle Fork Creek results exceeding benchmark and reference values. Middle Fork Creek conclusions are based on the one sampling event data collected during the field investigation. The data collected do not account for temporal variations and represent point estimates of exposure. The surface water results did not exceed WQC but several of the total metals were higher at SE-13 than the reference locations, likely due to suspended solids picked up in the sample. The sediment results for Middle Fork Creek exceeded the SQBs for RDX, arsenic, chromium, and manganese and several metals were substantially higher than the reference locations. However, these exceedances were not significant enough to adversely impact human health or the aquatic biota.

FIGURE 8-2 MIDDLE FORK CREEK WATERSHED RESULTS EXCEEDING BENCHMARK OR BACKGROUND VALUES

FIGURE 8-2. Middle Fork Creek Watershed Results Exceeding Benchmark or Background Values, JPG Firing Range Study, 7-11 Oct. 2002



SW-01	ug/L
**Cd	0.34400

SE-01	ug/g
Sb	0.407
As	13.10
Cd	0.219 B
Cr	31.20
Pb	15.10
Mn	500
V	37.0
Zn	33.2

SG-01	ug/L
TOT_Mg	17700
DIS_Mg	17800
TOT_Zn	3.500

SW-13	ug/L
*Ba	122.0
*Ca	92900
*Cu	5.520
*Ni	3.70
*Zn	12.500

SE-13	ug/g
RDX	0.300
Sb	0.474
As	8.82
Cd	0.1780 B
Cr	23.5
Pb	19.40
Mn	743
Zn	51.6

8.4.3 Big Creek Sampling Locations

The Big Creek drainage basin is just to the north of Middle Fork Creek drainage basin (See Figure 8-1). The drainage basin contains several impact fields and most of the Depleted Uranium Impact Area. There were three sampling locations on Big Creek; a reference sampling location (12), a sampling location a little over midway through JPG below the Depleted Uranium Impact Area near Morgan Road (14), and a downstream sampling location near the west perimeter road (02).

8.4.3.1 <u>Surface Water Results</u>

Surface water analytical results for all samples, along with the applicable Federal WQC and State WQSs are presented in Table 8-5. Big Creek surface water results are presented in Table 8-12.

8.4.3.1.1 Metals and Hardness

The only metal in the water samples to be substantially higher at SW-14 compared to both SW-12 (watershed reference) and the average reference locations was uranium. The concentration of uranium was 6-7 times higher. That would be expected immediately downstream of the Depleted Uranium Impact Area. Most of the metals results at SW-14 were lower than reference locations. The furthest downstream sampling location SW-02 near the installation boundary had several metals slightly higher than the watershed reference location SW-12. The only metals that were substantially higher than all reference locations at SW-02 were total lead, total manganese, total and dissolved uranium, total vanadium, and total zinc. For all of the metals just mentioned except for uranium, the dissolved fraction was well below the reference location concentrations.

8.4.3.1.2 Explosives and Degradates

The only explosive detected in Big Creek water samples was RDX at sampling location SW-02 (0.14 μg/L).

8.4.3.1.3 Perchlorate and Field Parameters

Perchlorate was not detected in Big Creek water samples. TOC and the field parameters were well within reference values and what would be required to support a healthy ecological community.

8.4.3.1.4 Water Quality Criteria Screening

There were no surface water results for Big Creek that exceeded Federal WQC or State WQSs.

TABLE 8-12 BIG CREEK SURFACE WATER RESULTS

PARAMETER	UNIT	SW-02	Watershed Reference SW-12	SW-14	Reference Average (SW-07-SW-12)	REGULATORY CRITERIA* FEDERAL AMBIENT WATER QUALITY CRITERIA CMC	CCC	INDIANA AMBIENT WATER QUALITY CRITERIA CMC	CCC
Explosives and Degradates									
HMX	µg/L	3.0 U	3.0 U	3.0 U	3.0	NA	330	No numeric criteria have been established for these compounds.	
RDX	µg/L	**0.140**	**0.040 J**	0.100 U	0.062	4000	190		
2,4,6-TNT	µg/L	0.030 U	0.030 U	0.030 U	0.03	570	130		
1,3-DNB	µg/L	0.090 U	0.090 U	0.090 U	0.09	110	30		
1,3,5-TNB	µg/L	0.030 U	0.030 U	0.030 U	0.03	30	14		
TETRYL	µg/L	0.50 U	0.50 U	0.50 U	0.5	NA	NA		
NB	µg/L	0.030 U	0.030 U	0.030 U	0.03	27,000			
2A-4,6-DNT	µg/L	0.10 U	0.10 U	0.10 U	0.1	NA	NA		
4A-2,6-DNT	µg/L	0.10 U	0.10 U	0.10 U	0.1	NA	NA		
2,6-DNT	µg/L	0.010 U	0.010 U	0.010 U	0.01	18,500	NA		
2,4-DNT	µg/L	0.020 U	0.020 U	0.020 U	0.02	330	230		
2-NT	µg/L	0.090 U	0.090 U	0.090 U	0.09	NA	NA		
3-NT	µg/L	0.090 U	0.090 U	0.090 U	0.09	NA	NA		
4-NT	µg/L	0.090 U	0.090 U	0.090 U	0.09	NA	NA		
Nitroglycerin	µg/L	0.090 U	0.090 U	0.090 U	0.09	1700	200		
WP	µg/L	0.024 U	0.024 U	0.024 U	0.024	0.5	0.1		
Metals									
Hardness	mg/L	125	148	120	160	-	-	-	-
Antimony (Total/*Dissolved*)	µg/L	**0.0860** ***0.0895***	**0.0861** ***0.0844***	**0.0830** ***0.0820***	0.1036 0.0997	- 180	- 30	-	-
Arsenic	µg/L	**0.917** ***0.873***	**0.785** ***0.738***	**0.747** ***0.777***	0.983 1.027	- 340	- 150	360 -	190 -
Barium	µg/L	**52.5** ***47.8***	**55.2** ***53.7***	**43.8** ***45.0***	57.8 56.3	- 1000	1000	- -	- -
Cadmium	µg/L	**0.03220** ***0.01190***	**0.01740** ***0.01610***	**0.00991** ***0.00922***	0.04352 0.02993	- 4.3	- 2.2	4 -	1.1 -
Calcium	µg/L	**34600** ***34500***	**43900** ***43600***	**34700** ***36100***	47400 45950	- -	- -	- -	- -
Chromium	µg/L	**0.4620** *0.0240 U*	**0.3390** ***0.2900***	**0.1770** ***0.0384***	0.4355 0.3898	- 570	- 74	1737 -	207 -
Copper	µg/L	**1.460** ***1.190***	**1.120** ***1.140***	**1.310** ***1.240***	1.066 1.030	- 13	- 9	18 -	9 -
Lead	µg/L	**1.46000** ***0.00795***	**0.23500** ***0.22500***	**0.03660** ***0.00569***	0.41493 0.05072	- 65	- 2.5	82 -	3 -
Magnesium	µg/L	**9400** ***9370***	**9560** ***9550***	**7670** ***7830***	11502 11025	- -	- -	- -	- -
Manganese	µg/L	**113.00** ***17.00***	**37.10** ***34.90***	**38.40** ***34.60***	56.58 39.48	- 50	- -	- -	- -
Mercury	µg/L	**0.003640** ***0.002270***	**0.002140** ***0.002160***	**0.00207** ***0.00195***	0.001783 0.001508	- 1.4	- 0.77	2.4 -	0.012 -
Molybdenum	µg/L	**0.397** ***0.473***	**0.493** ***0.565***	**0.463** ***0.472***	1.055 0.997	- 16000	- 370	- -	- -
Nickel	µg/L	**2.07** ***1.70***	**2.01** ***2.28***	**1.85** ***1.72***	2.20 2.29	- 470	- 52	1418 -	158 -
Silver	µg/L	**0.02640 B** ***0.02310 B***	**0.00858 B** ***0.00841B***	**0.01050 B** ***0.01160 B***	0.05208 0.04755	- 3.4	- -	2 -	- -
Uranium	µg/L	**1.140** ***1.060***	**0.640** ***0.653***	**4.080** ***4.330***	0.717 0.697	- 46	- 2.6	- -	- -
Vanadium	µg/L	**1.340** ***0.537***	**0.784** ***0.688***	**0.631** ***0.582***	0.809 0.663	- 280	- 20	- -	- -
Zinc	µg/L	**3.680** ***0.423***	**1.460** ***1.660***	**0.750** ***0.458***	1.573 1.581	- 120	- 120	117 -	106 -
Other Parameters									
Perchlorate	µg/L	1.0 U	1.0 U	1.0 U	1.0	5000	600	-	-
TOC	mg/L	6.4	5.6	**5.6**	6.1	-	-	-	-
pH (Field, Lab)	s.u.	7.28	8.22	7.88		6.5 - 9.0		-	
D.O. (Field)	mg/L	2.91	13.21	11.2		-	-	-	-
Conductivity (Field)	µ-ohm	208	290	220		-	-	-	-
Temperature (Field)	Deg.Cel.	14.61	14.39	14.53		-	-	-	-

*-For complete citations see Table 8-3. Underlining-represents results substantially above reference (above all reference values). **Bold**-represents results above detection limit. **B**-represents parameter was also detected in laboratory blank for that run. **J**-estimate value below reporting limit. **NA**-not available. **U**-under detection limit.

8.4.3.2 Sediment Results

Sediment analytical results for all samples, along with the applicable SQBs, are presented in Table 8-6 and Big Creek results are presented in Table 8-13. Big Creek sediment analytical results are discussed below.

8.4.3.2.1 Metals

The sediment metals results for the furthest downstream sampling location on Big Creek (SE-02) were lower than the watershed reference location (SE-12) except for barium and nickel being slightly but not substantially higher. The sampling location just downstream of the Depleted Uranium Impact Area (SE-14) had metals concentrations in the sediment substantially higher than the watershed reference location (SE-12) and the average reference locations for nearly all metals. Cadmium and silver were the only metals that were lower than those of the reference locations. Barium, copper, and lead were only higher than the watershed reference location (SE-12) but not higher than all reference location values. All other metals were substantially higher than all reference locations (antimony, arsenic, chromium, manganese, mercury, nickel, uranium, vanadium, and zinc). Why so many metals were substantially higher in the sediment and not in the water sample at sampling location (14) or the sediment in the further downstream sampling location (SE-2) was not at all clear. The benthic macroinvertebrates discussed later were not adversely affected by any of the elevated metals in the sediment.

8.4.3.2.2 Explosives and Degradates

There were only two of the explosives detected in the sediments from Big Creek (RDX and 2,4,6-TNT). They were nearly the same concentration at all three sampling locations to include the reference location (12) and lower than the average reference locations. The concentrations were 0.28 µg/g , 0.28 µg/g, and 0.22 µg/g and 0.047 µg/g, 0.047 µg/g, and 0.051 µg/g for RDX and 2,4,6-TNT respectively at sampling locations 02, 12, and 14 respectively. The average of the reference locations was 0.545 µg/g, and 0.117 µg/g for RDX and 2,4,6-TNT respectively.

8.4.3.2.3 Perchlorate

Perchlorate was not detected in the sediments of the Big Creek watershed. Total organic matter (TOM) was less than 1%.

8.4.3.2.4 Sediment Quality Benchmarks

The sediment results and SQBs for Big Creek are presented in Table 8-13. Big Creek sediment sample concentrations were compared to SQBs. The explosive RDX in sediment samples SE-02 (0.28 µg/g), SE-12 (0.28 µg/g), and SE-14 (0.22 µg/g) all exceeded the SQB of 0.190 µg/g for RDX. However, the average reference location concentration of 0.545 µg/g exceeded the SQB even more. There were two metals that exceeded SQBs in Big Creek sediments: arsenic SQB of 5.9 µg/g at SE-02 with 7.71 µg/g arsenic, SE-12 with 9.64 µg/g arsenic, and SE-14 with 23.8 µg/g arsenic, and manganese SQB of 460 µg/g at SE-14 with 639 µg/g manganese. The conservative SQBs were only slightly exceeded, and chemistry data alone can only indicate that there is a possibility of an adverse impact on the ecological health. Benthic macroinvertebrate data were used to make the final determination.

TABLE 8-13. BIG CREEK SEDIMENT RESULTS

PARAMETER	UNIT	SE-02	Watershed Reference SE-12	SE-14	Reference Average (SE-7-SE-12)	REGULATORY CRITERIA* SEDIMENT QUALITY BENCHMARK
Explosives and Degradates						
HMX	µg/g	0.050 U	0.050 U	0.050 U	0.092	0.330[1]
RDX	µg/g	**0.280**	**0.280**	**0.220**	0.545	0.190[1]
2,4,6-TNT	µg/g	**0.047**	**0.047**	**0.051**	0.117	0.52[1]
1,3-DNB	µg/g	0.020 U	0.020 U	0.020 U	0.020	0.04[1]
1,3,5-TNB	µg/g	0.020 U	0.020 U	0.020 U	0.020	0.02[1]
TETRYL	µg/g	0.020 U	0.020 U	0.020 U	0.020	NA
NB	µg/g	0.020 U	0.020 U	0.020 U	0.020	27.0[1]
2A-4,6-DNT	µg/g	0.020 U	0.020 U	0.020 U	0.020	NA
4A-2,6-DNT	µg/g	0.050 U	0.050 U	0.050 U	0.050	NA
2,6-DNT	µg/g	0.010 U	0.010 U	0.010 U	0.010	18.5[1]
2,4-DNT	µg/g	0.020 U	0.020 U	0.020 U	0.020	0.230[1]
2-NT	µg/g	0.020 U	0.020 U	0.020 U	0.020	NA
3-NT	µg/g	0.020 U	0.020 U	0.020 U	0.020	NA
4-NT	µg/g	0.060 U	0.060 U	0.070 U	0.063	NA
Nitroglycerin	µg/g	0.050 U	0.050 U	0.050 U	0.050	NA
WP	µg/g	0.0010 U	0.0010 U	0.0010 U	0.001	0.26[5]
Moisture (WP only)	Percent	**20**	**22**	**15**	19	NA
Metals						
Antimony	µg/g	**0.259**	**0.31**	**0.485**	0.244	NA
Arsenic	µg/g	**7.71**	**9.64**	**23.80**	5.78	5.9[2]
Barium	µg/g	**200**	**149**	**263**	206	500[3]
Cadmium	µg/g	**0.0955 B**	**0.108 B**	0.0587 U	0.0946	0.596[2]
Chromium	µg/g	**11.70**	**12.70**	**24.9**	11.27	26[3]
Copper	µg/g	**2.77**	**3.07**	**5.72**	4.18	16[3]
Lead	µg/g	**8.46**	**9.04**	**11.70**	7.84	31[3]
Manganese	µg/g	**239**	**327**	**639**	265	460[3]
Mercury	µg/g	**0.01040**	**0.01380**	**0.02110 B**	0.01440	0.174[2]
Molybdenum	µg/g	**0.782**	**0.881**	**1.470**	0.741	NA
Nickel	µg/g	**4.14**	**3.69**	**6.72**	4.18	16[3]
Silver	µg/g	**0.0465**	**0.1020**	**0.0674**	0.1017	1[4]
Uranium	µg/g	**0.517**	**0.531**	**3.050**	0.562	NA
Vanadium	µg/g	**23.4**	**27.6**	**49.4**	22.0	NA
Zinc	µg/g	**21.7**	**21.7**	**45.8**	18.8	120[3]
Moisture	Percent	21.5	20.2	20.7	18.6	NA
Other Parameters						
Total Organic Matter	Percent	**0.7**	**0.8**	**0.9**	0.8	NA
Perchlorate	µg/g	0.013 U	0.013 U	0.013 U	0.013	NA
Benthic Macroinvertebrates						
Number of species		19	16	17	NA	NA
Number of individuals		196	210	148	NA	NA
EPT/total individuals		76%	35%	49%	NA	NA
Diversity H		2.15	2.26	2.63	NA	NA

*-For complete citations see Table 8-3. Underlining-represents results substantially above reference (above all reference values). **Bold**-represents results above detection limit. **B**-represents parameter was also detected in laboratory blank for that run. **U**-under detection limit.

Highlighted represents exceedance of SQB

8.4.3.3 Benthic Macroinvertebrate Results

The benthic macroinvertebrate results for all samples are presented in Table 8-7 and results for Big Creek are summarized in Table 8-13. There were no discernable differences in the benthic macroinvertebrate population in Big Creek compared to the reference locations. In fact, the benthic macroinvertebrate results indicate there is a slight increase in diversity, number of taxa, number of individuals, and number of pollution intolerant organisms at the downstream locations compared to the reference locations. There was no sign of adverse impact on the benthic macroinvertebrate population in Big Creek.

8.4.3.4 Big Creek Summary

Figure 8-3 shows the Big Creek results exceeding benchmark or references values. Big Creek conclusions are based on the one sampling event data collected during the field investigation. The data collected do not account for temporal variations and represent point estimates of exposure. The surface water results did not exceed Federal WQC or State WQSs, but some of the total metals were higher at SW-02 than the reference locations even though dissolved metals were not higher. An excess of suspended solids may have been picked up in the sample. The sediment results for Big Creek exceeded SQBs for RDX, arsenic, and manganese. Several sediment metals were substantially higher than the reference locations at SE-14 but decreased again by the downstream sampling location SE-02. There were no adverse impacts on the human health or the benthic macroinvertebrate population.

8.4.4 Marble Creek Sampling Location

The Marble Creek drainage basin is just to the north of the Big Creek drainage basin (See Figure 8-1). The drainage basin contains several impact fields but is much smaller than other drainage basins, originating less than half way across JPG. Therefore, Marble Creek did not have its own reference location. There was only one downstream sampling location on Marble Creek near the west perimeter road (sampling location 03). The average results of the six reference locations on other watersheds were used for comparison with Marble Creek results.

8.4.4.1 Surface Water Results

Surface water analytical results for all samples, along with applicable Federal WQC and State WQSs, are presented in Table 8-6 and the results for Marble Creek are presented in Table 8-14. The Marble Creek analytical results are discussed below.

8.4.4.1.1 Metals and Hardness

Both total and dissolved barium and manganese were the only surface water metals results that were substantially higher in the Marble Creek downstream sampling location (SW-03) than the reference locations. Total and dissolved mercury were only slightly higher than the reference average and the other 14 metals were all lower than the reference average.

FIGURE 8-3 MARBLE & BIG CREEK WATERSHED RESULTS EXCEEDING BENCHMARK OR BACKGROUND VALUES

FIGURE 8-3. Marble & Big Creek Watershed Results Exceeding Benchmark or Background Values, JPG Firing Range Study, 7-11 Oct. 2002

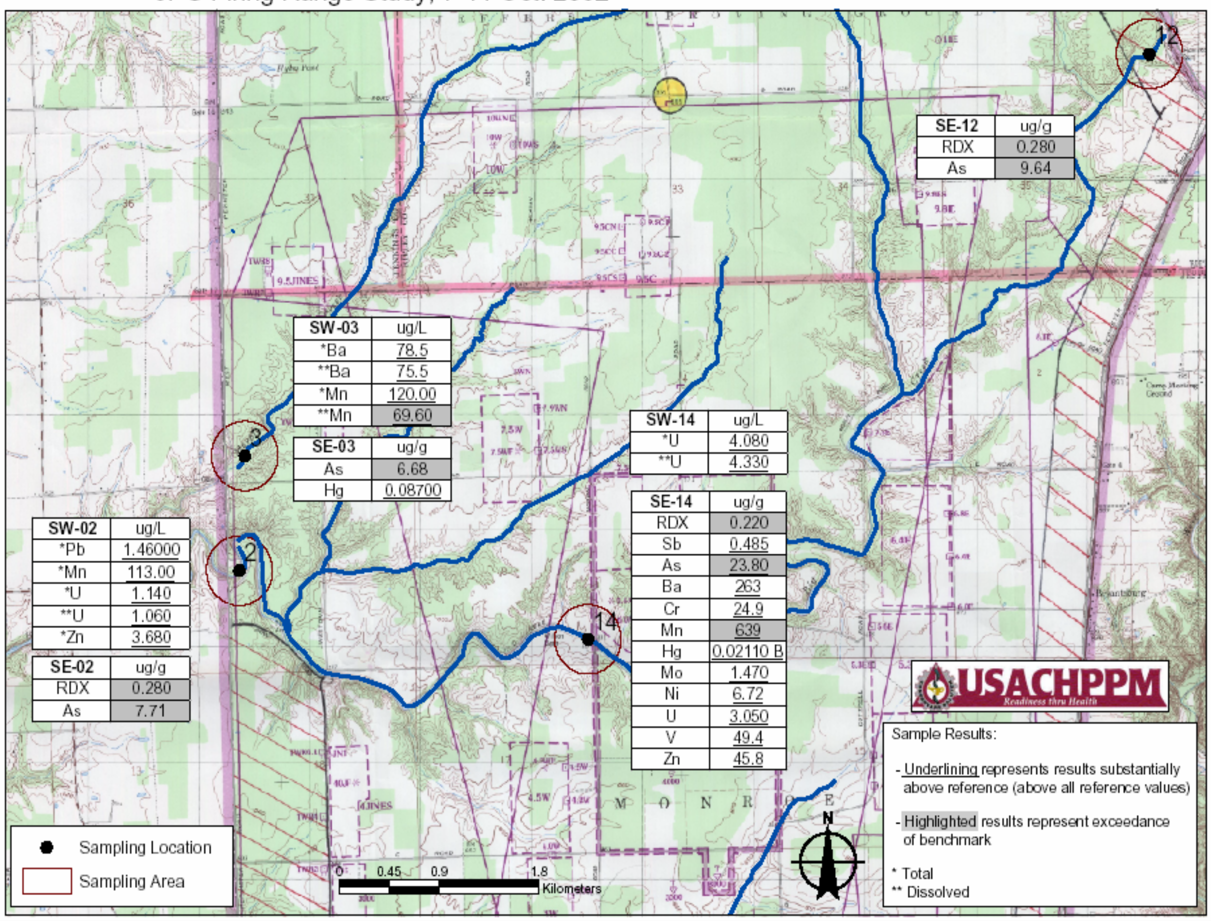


TABLE 8-14. MARBLE CREEK SURFACE WATER RESULTS

PARAMETER	UNIT	SW-3	Reference Average (SW7-SW12)	REGULATORY CRITERIA*			
				FEDERAL AMBIENT WATER QUALITY CRITERIA		INDIANA AMBIENT WATER QUALITY CRITERIA	
				CMC	CCC	CMC	CCC
Explosives and Degradates							
HMX	µg/L	3.0 U	3.0	NA	330	No numeric criteria have been established for these compounds.	
RDX	µg/L	**0.027 J**	0.062	4000	190		
2,4,6-TNT	µg/L	0.030 U	0.03	570	130		
1,3-DNB	µg/L	0.090 U	0.09	110	30		
1,3,5-TNB	µg/L	0.030 U	0.03	30	14		
TETRYL	µg/L	0.50 U	0.5	NA	NA		
NB	µg/L	0.030 U	0.03	27,000			
2A-4,6-DNT	µg/L	0.10 U	0.1	NA	NA		
4A-2,6-DNT	µg/L	0.10 U	0.1	NA	NA		
2,6-DNT	µg/L	0.010 U	0.01	18,500	NA		
2,4-DNT	µg/L	0.020 U	0.02	330	230		
2-NT	µg/L	0.090 U	0.09	NA	NA		
3-NT	µg/L	0.090 U	0.09	NA	NA		
4-NT	µg/L	0.090 U	0.09	NA	NA		
Nitroglycerin	µg/L	0.090 U	0.09	1700	200		
WP	µg/L	0.024 U	0.024	0.5	0.1		
Metals							
Hardness	mg/L	120	160	-	-	-	-
Antimony (Total/*Dissolved*) [1]	µg/L	**0.0599** ***0.0644***	0.1036 0.0997	- 180	- 30	-	-
Arsenic	µg/L	**0.688** ***0.678***	0.983 1.027	- 340	- 150	360 -	190 -
Barium	µg/L	**78.5** ***75.5***	57.8 56.3	- 1000	1000	- -	- -
Cadmium	µg/L	**0.01480** ***0.00885***	0.04352 0.02993	- 4.3	- 2.2	4 -	1.1 -
Calcium	µg/L	**32300** ***32600***	47400 45950	- -	- -	- -	- -
Chromium	µg/L	0.0240 U *0.0240 U*	0.4355 0.3898	- 570	- 74	1737 -	207 -
Copper	µg/L	**0.698** ***0.592***	1.066 1.030	- 13	- 9	18 -	9 -
Lead	µg/L	**0.15400** *0.00500 U*	0.41493 0.05072	- 65	- 2.5	82 -	3 -
Magnesium	µg/L	**9250** ***9380***	11502 11025	- -	- -	- -	- -
Manganese	µg/L	**120.00** ***69.60***	56.58 39.48	- 50	- -	- -	- -
Mercury	µg/L	**0.002340** ***0.001640***	0.001783 0.001508	- 1.4	- 0.77	2.4 -	0.012 -
Molybdenum	µg/L	**0.403** ***0.413***	1.055 0.997	- 16000	- 370	- -	- -
Nickel	µg/L	**1.65** ***1.55***	2.20 2.29	- 470	- 52	1418 -	158 -
Silver	µg/L	**0.01400 B** ***0.01250 B***	0.05208 0.04755	- 3.4	- -	2 -	- -
Uranium	µg/L	**0.236** ***0.231***	0.717 0.697	- 46	- 2.6	- -	- -
Vanadium	µg/L	**0.303** ***0.107***	0.809 0.663	- 280	- 20	- -	- -
Zinc	µg/L	**1.260** ***0.370***	1.573 1.581	- 120	- 120	117 -	106 -
Other Parameters							
Perchlorate	µg/L	1.0 U	1.0	5000	600	-	-
TOC	mg/L	6.8	6.1	-	-	-	-
pH (Field, Lab)	s.u.	6.98		6.5 - 9.0		-	
D.O. (Field)	mg/L	2.7		-	-	-	-
Conductivity (Field)	µohm	205		-	-	-	-
Temperature (Field)	Deg.Cel.	16.29		-	-	-	-

*-For complete citations see Table 8-3. Underlining-represents results substantially above reference (above all reference values). **Bold**-represents results above detection limit.
B-represents parameter was also detected in laboratory blank for that run. **J**-estimate value below reporting limit. **NA**-not available. **U**-under detection limit.

8.4.4.1.2 Explosives and Degradates

There were no explosives above the reporting limit in the Marble Creek surface water sample (SW-03). RDX was estimated at 0.027 µg/L because the reporting limit was 0.10 µg/L. The reporting limit was 5 times the method detection limit.

8.4.4.1.3 Perchlorate and Field Parameters

There was no perchlorate detected in the Marble Creek water sample. TOC and the field parameters were well within reference values and what would be required to support a healthy ecological community.

8.4.4.1.4 Water Quality Criteria Screening

The only exceedance in the surface water results for Marble Creek was a dissolved manganese National Secondary Drinking Water Standard of 50 µg/L. The SW-3 result was 69.6 µg/L dissolved manganese.

8.4.4.2 Sediment Results

The sediment analytical results for all samples, along with the applicable SQBs, are presented in Table 8-6 and sediment results for Marble Creek are presented in Table 8-15. The Marble Creek sediment analytical results are discussed below.

8.4.4.2.1 Metals

The sediment mercury concentration for Marble Creek (SE-03) was the only sediment metal that was substantially higher than the average reference value. The mercury sediment concentration value was 6 times the reference value. The arsenic sediment concentration was only slightly higher than the reference average and all 13 other sediment metals were lower than the reference average.

8.4.4.2.2 Explosives and Degradates

There were no explosives detected above the reporting limit in the sediment of Marble Creek.

8.4.4.2.3 Perchlorate

Perchlorate was not detected in the sediments of the Marble Creek watershed. TOM was less than 1%.

TABLE 8-15 MARBLE CREEK SEDIMENT RESULTS

PARAMETER	UNIT	SE-3	Reference Average (SE7-SE12)	REGULATORY CRITERIA* SEDIMENT QUALITY BENCHMARK
Explosives and Degradates				
HMX	µg/g	0.050 U	0.092	0.330[1]
RDX	µg/g	**0.009 J**	0.545	0.190[1]
2,4,6-TNT	µg/g	0.010 U	0.117	0.52[1]
1,3-DNB	µg/g	0.020 U	0.020	0.04[1]
1,3,5-TNB	µg/g	0.020 U	0.020	0.02[1]
TETRYL	µg/g	0.020 U	0.020	NA
NB	µg/g	0.020 U	0.020	27.0[1]
2A-4,6-DNT	µg/g	0.020 U	0.020	NA
4A-2,6-DNT	µg/g	0.050 U	0.050	NA
2,6-DNT	µg/g	0.010 U	0.010	18.5[1]
2,4-DNT	µg/g	0.020 U	0.020	0.230[1]
2-NT	µg/g	0.020 U	0.020	NA
3-NT	µg/g	0.020 U	0.020	NA
4-NT	µg/g	0.040 U	0.063	NA
Nitroglycerin	µg/g	0.050 U	0.050	NA
WP	µg/g	0.0010 U	0.001	0.26[5]
Moisture (WP only)	Percent	20	19	NA
Metals				
Antimony	µg/g	**0.185**	0.244	NA
Arsenic	µg/g	**6.68**	5.78	5.9[2]
Barium	µg/g	**165**	206	500[3]
Cadmium	µg/g	**0.0927 B**	0.0946	0.596[2]
Chromium	µg/g	**9.98**	11.27	26[3]
Copper	µg/g	**2.83**	4.18	16[3]
Lead	µg/g	**4.88**	7.84	31[3]
Manganese	µg/g	**143**	265	460[3]
Mercury	µg/g	<u>**0.08700**</u>	0.01440	0.174[2]
Molybdenum	µg/g	**0.550**	0.741	NA
Nickel	µg/g	**2.33**	4.18	16[3]
Silver	µg/g	**0.0416**	0.1017	1[4]
Uranium	µg/g	**0.354**	0.562	NA
Vanadium	µg/g	**15.2**	22.0	NA
Zinc	µg/g	**17.1**	18.8	120[3]
Moisture	Percent	21.2	18.6	NA
Other Parameters				
Total Organic Matter	Percent	0.7	0.8	NA
Perchlorate	µg/g	0.013 U	0.013	NA
Benthic Macroinvertebrates				
Number of taxa		9	17	NA
Number of Individuals		21	148	NA
EPT/Total Individuals		48%	49%	NA
Diversity H		2.26	2.63	NA

*-For complete citations see Table 8-3. <u>Underlining</u>-represents results substantially above reference (above all reference values). **Bold**-represents results above detection limit. **B**-represents parameter was also detected in laboratory blank for that run. **J**-estimate value below reporting limit. **NA**-not available. **U**-under detection limit.

Highlighted represents exceedance of SQB

8.4.4.2.4 Sediment Quality Benchmarks

The only SQB exceeded in the sediment results for Marble Creek was arsenic. The SQB for arsenic is 5.9 µg/g and the concentration in the sediment sample was 6.68 µg/g arsenic. The conservative SQB was only slightly exceeded, and chemistry data alone can only indicate that there is a possibility of an adverse impact on the ecological health. Benthic macroinvertebrate data were used to make the final determination.

8.4.4.3 Benthic Macroinvertebrate Results

The benthic macroinvertebrate population in Marble Creek was very sparse and only one of the three samples could be collected. A similar diversity, number of species, and mix of pollution intolerant species were present compared to reference locations especially sampling locations 8 and 9 where the lack of substrate, size of creek, and lack of organisms made it impossible to collect three similar subsamples.

8.4.4.4 Marble Creek Summary

Figure 8-3 shows the Marble Creek results exceeding benchmark or background values. Marble Creek conclusions are based on the one sampling event data collected during the field investigation. The data collected do not account for temporal variations and represent point estimates of exposure. The surface water results did not exceed Federal WQC or State WQSs and only two of the metals (total and dissolved barium and manganese) were substantially higher than the average reference values. The sediment results for Marble Creek exceeded the SQB for arsenic. The sediment mercury was substantially higher than the average reference value. All the other surface water and sediment metals concentrations were lower than the average reference value. The surface water and sediment explosives were below the reporting limit for explosives. There were no adverse impacts on human health or the benthic macroinvertebrate population.

8.4.5 Little Graham Creek Watershed and Sampling Locations

This watershed is in the north-central part of the installation. Several impact fields traverse the watershed from north to south. One tributary of Little Graham Creek originates off post to the east, flows southwest across the post, and then flows off post toward the southwest. The locations of the Little Graham Creek sampling locations appear in Figure 8-1. Little Graham Creek sampling location SW-11 is the upstream reference location. It is located along the eastern boundary of the post. Sampling location SW-15 is located in the middle of the basin, at the intersection of Horse and Poplar Branch and the main channel. Several impact fields and safety fans are between sampling locations SW-11 and SW-15. Sampling location SW-04 is located along the western boundary. It is the furthest downstream sampling location and it receives drainage from the entire Little Graham Creek watershed. One surface water grab sample was collected at each sampling location but sampling location 04 also had a duplicate sample collected (20).

8.4.5.1 Little Graham Creek Surface Water Results

Analytical results for all JPG surface water samples are presented in Table 8-5. The Federal WQC and State WQSs applicable to JPG surface waters are also included in this table for easy comparison. The Little Graham Creek surface water analytical sample results along with the reference for the Little Graham Creek watershed (SW-11), and reference average for all sampled watersheds on JPG are presented in Table 8-16. Little Graham Creek surface water results are discussed below.

8.4.5.1.1 Metals and Hardness

The Little Graham Creek surface water samples had moderate hardness values of 116 to 128 mg/L, but were lower than the average reference locations which was 160 mg/L.

In general, individual total metals concentrations exceeded their dissolved metals counterparts. However, a number of metals (antimony, arsenic, cadmium, calcium, copper, magnesium, molybdenum, silver, and uranium) had one or more total metal concentrations below their dissolved counterparts (see Table 8-16). Most metals were detected at low levels, some at or near the corresponding metal reporting limit.

The Little Graham Creek surface water metal results (SW-15 and SW-04) were similar to the reference watershed location (SW-11), and to the average reference concentrations for most metals (see Table 8-16). There were only three metals, both total and dissolved, that were substantially higher downstream than both the watershed reference location (SW-11) and the average reference locations. They were arsenic, barium, and manganese at sampling location SW-15, the mid-installation location. However, all three decreased to below reference values by the furthest downstream location (SW-04). Calcium, magnesium, and mercury were only slightly higher as the downstream location (SW-04) than SW-11 but not higher than average reference values. Generally, the metals showed a consistent decrease in concentration from upstream (SW-11) to downstream (SW-04) in both total and dissolved forms.

8.4.5.1.2 Explosives and Degradates

No explosives or explosive degradate compounds were found in Little Graham Creek surface water samples above reporting limits.

8.4.5.1.3 Perchlorate, TOC, and Field Parameters

Perchlorate and TOC concentrations, along with miscellaneous field parameter data, are shown in Table 8-16. Perchlorate was not detected in any Little Graham Creek samples. TOC ranged from 6.0 to 6.8 mg/L in Little Graham Creek surface water samples. The pH of the water was slightly alkaline, with values ranging from 7.57 to 7.69. Conductivity ranged from 231 to 407 µohm. The highest conductivity value (407 µohm) was found in the reference sample for Little Graham Creek (SW-11). Dissolved oxygen concentrations increased in the downstream samples. TOC and the field parameters were well within reference values and what would be required to support a healthy ecological community.

TABLE 8-16. LITTLE GRAHAM CREEK SURFACE WATER RESULTS

							REGULATORY CRITERIA*			
			Watershed Reference			Reference Average (SW7-SW12)	FEDERAL AMBIENT WATER QUALITY CRITERIA		INDIANA AMBIENT WATER QUALITY CRITERIA	
PARAMETER	UNIT	SW-04	SW-11	SW-15	SW-20**		CMC	CCC	CMC	CCC
Explosives and Degradates										
HMX	µg/L	3.0 U	3.0 U	3.0 U	3.0 U	3.0	NA	330	No numeric criteria have been established for these compounds.	
RDX	µg/L	0.100 U	**0.036 J**	**0.037 J**	0.100 U	0.062	4000	190		
2,4,6-TNT	µg/L	0.030 U	0.030 U	0.030 U	0.030 U	0.03	570	130		
1,3-DNB	µg/L	0.090 U	0.090 U	0.090 U	0.090 U	0.09	110	30		
1,3,5-TNB	µg/L	0.030 U	0.030 U	0.030 U	0.030 U	0.03	30	14		
TETRYL	µg/L	0.50 U	0.50 U	0.50 U	0.50 U	0.5	NA	NA		
NB	µg/L	0.030 U	0.030 U	0.030 U	0.030 U	0.03	27,000			
2A-4,6-DNT	µg/L	0.10 U	0.10 U	0.10 U	0.10 U	0.1	NA	NA		
4A-2,6-DNT	µg/L	0.10 U	0.10 U	0.10 U	0.10 U	0.1	NA	NA		
2,6-DNT	µg/L	0.010 U	0.010 U	0.010 U	0.010 U	0.01	18,500	NA		
2,4-DNT	µg/L	0.020 U	0.020 U	0.020 U	0.020 U	0.02	330	230		
2-NT	µg/L	0.090 U	0.090 U	0.090 U	0.090 U	0.09	NA	NA		
3-NT	µg/L	0.090 U	0.090 U	0.090 U	0.090 U	0.09	NA	NA		
4-NT	µg/L	0.090 U	0.090 U	0.090 U	0.090 U	0.09	NA	NA		
Nitroglycerin	µg/L	0.090 U	0.090 U	0.090 U	0.090 U	0.09	1700	200		
WP	µg/L	0.024 U	0.024 U	0.024 U	0.024 U	0.024	0.5	0.1		
Metals										
Hardness	mg/L	128	116	128	128	160	-	-	-	-
Antimony (Total/*Dissolved*)	µg/L	**0.0792** ***0.0836***	**0.1510** ***0.1580***	**0.0703** ***0.0864***	**0.0947** ***0.1080***	0.1036 0.0997	- 180	- 30	-	-
Arsenic	µg/L	**0.758** ***0.771***	**1.050** ***0.997***	**2.000** ***1.340***	**0.740** ***0.713***	0.983 1.027	- 340	- 150	360 -	190 -
Barium	µg/L	**44.6** ***44.1***	**56.5** ***54.9***	**111.0** ***72.9***	**44.8** ***44.1***	57.8 56.3	- 1000	1000	- -	- -
Cadmium	µg/L	**0.00959** ***0.00989***	**0.01980** ***0.02210***	**0.02100** ***0.01870***	**0.01280** ***0.00671***	0.04352 0.02993	- 4.3	- 2.2	4 -	1.1 -
Calcium	µg/L	**36300** ***36400***	**33300** ***33300***	**39600** ***39000***	**37000** ***36400***	47400 45950	- -	- -	- -	- -
Chromium	µg/L	0.0240 U *0.0240 U*	**0.7540** ***0.1250***	0.0240 U *0.0240 U*	**0.0322** *0.0240 U*	0.4355 0.3898	- 570	- 74	1737 -	207 -
Copper	µg/L	**1.110** ***1.050***	**1.370** ***1.260***	**0.758** ***0.893***	**1.090** ***1.030***	1.066 1.030	- 13	- 9	18 -	9 -
Lead	µg/L	**0.05550** *0.00500 U*	**2.01000** ***0.03410***	**0.10000** ***0.02270***	**0.03320** ***0.00500 U***	0.41493 0.05072	- 65	- 2.5	82 -	3 -
Magnesium	µg/L	**8910** ***8910***	**8050** ***8100***	**7520** ***7420***	**9090** ***9130***	11502 11025	- -	- -	- -	- -
Manganese	µg/L	**31.70** ***23.70***	**89.20** ***72.70***	**939.00** ***401.00***	**29.00** ***24.90***	56.58 39.48	- 50	- -	- -	- -
Mercury	µg/L	**0.001970** ***0.001830***	**0.001870** ***0.001330***	**0.00164** ***0.00156***	**0.00189** ***0.00166***	0.001783 0.001508	- 1.4	- 0.77	2.4 -	0.012 -
Molybdenum	µg/L	**0.479** ***0.502***	**0.858** ***0.845***	**0.527** ***0.529***	**0.498** ***0.479***	1.055 0.997	- 16000	- 370	- -	- -
Nickel	µg/L	**1.72** ***1.54***	**1.75** ***1.67***	**1.58** ***1.58***	**1.60** ***1.57***	2.20 2.29	- 470	- 52	1418 -	158 -
Silver	µg/L	**0.18200** ***0.20900***	**0.22000** ***0.25800***	**0.24900** ***0.24300***	**0.15400** ***0.17100***	0.05208 0.04755	- 3.4	- -	2 -	- -
Uranium	µg/L	**0.312** ***0.319***	**0.665** ***0.650***	**0.253** ***0.327***	**0.320** ***0.313***	0.717 0.697	- 46	- 2.6	- -	- -
Vanadium	µg/L	**0.441** ***0.371***	**1.430** ***0.983***	**0.475** ***0.450***	**0.431** ***0.370***	0.809 0.663	- 280	- 20	- -	- -
Zinc	µg/L	**0.628** ***0.293***	**1.740** ***0.484***	**1.100** ***0.450***	**1.670** ***0.335***	1.573 1.581	- 120	- 120	117 -	106 -
Other Parameters										
Perchlorate	µg/L	1.0 U	1.0 U	1.0 U	1.0 U	1.0	5000	600	-	-
TOC	mg/L	6.0	6.1	**6.8**	**6.1**	6.1	-	-	-	-
pH (Field, Lab)	s.u.	7.57	7.69	7.62	7.6		6.5 - 9.0		-	
D.O. (Field)	mg/L	9.5	8.4	8.4	9.17		-	-	-	-
Conductivity (Field)	µ-ohm	231	407	14.57	231		-	-	-	-
Temperature (Field)	Deg.Cel.	13.66	14.2	259	13.66		-	-	-	-

*-For complete citations see Table 8-3. **-SW-20 is a duplicate sample for SW-04. Underlining-represents results substantially above reference (above all reference values). **Bold**-represents results above detection limit. **B**-represents parameter was also detected in laboratory blank for that run. **J**-estimate value below reporting limit. **NA**-not available. **U**-under detection limit.

Highlighted represents exceedance of the secondary drinking water standard of 50 µg/L dissolved manganese.

8.4.5.1.4 Water Quality Criteria Screening

There were no parameters that exceeded the Federal WQC or State WQSs in Little Graham Creek.

8.4.5.2 Little Graham Creek Sediment Results

Little Graham Creek sediment analytical results, along with the SQBs, are presented in Table 8-17. The Little Graham Creek sediment analytical sample results are discussed below.

8.4.5.2.1 Metals

The Little Graham Creek sediment metals concentrations were detected at low levels in all Little Graham Creek sediment samples. Nearly all metals in Little Graham Creek were at least slightly higher in concentration at the downstream locations (SE-04 and SE-15) compared to the watershed reference (SE-11). Silver was the only exception. The metals that were substantially higher than the average reference locations at SE-04 (averaged with duplicate SE-20) were cadmium, chromium, vanadium, and zinc. The metals that were substantially higher than the average reference locations at SE-15 were arsenic, cadmium, chromium, lead, mercury, nickel, vanadium, and zinc. None of the metals increased by an order of magnitude from the upstream sampling location (SE-11) or average reference locations to the downstream sampling locations. Metals in the surrounding rocks and soil along with differential leaching rates may account for the existing variability in sediment metal concentrations. Since there was no substantial increase in the surface water metals in the furthest downstream sampling location (SW-04) and only arsenic, barium, and manganese had substantial increases at the mid-installation sampling location (SE-15), it is unlikely the increases in the sediment metals is significant. The benthic macroinvertebrate population was healthy at the downstream locations on Little Graham Creek.

8.4.5.2.2 Explosives and Degradates

Two of the explosives were detected in the sediment samples of Little Graham Creek and the reference locations. None of the explosives in the sediment were higher in Little Graham Creek than they were in the reference locations. The concentrations for sample SE-15 (mid-installation sample location) was 0.110 µg/g RDX and 0.038 µg/g 2,4,6-TNT, the average of SE-04 and it duplicate SE-20 was 0.165 µg/g RDX and 0.035 µg/g 2,4,6-TNT. The average of reference locations was 0.545 µg/g RDX, and 0.117 µg/g 2,4,6-TNT.

RDX and 2,4,6-TNT were found in the reference location (SE-11) at concentrations of 0.350 µg/g and 0.054 µg/g, respectively. Explosives detections at the reference location were clearly unexpected. The sample was collected very close to the eastern boundary where Little Graham Creek begins to flow onto the installation. Farm fields are upstream. See discussion in Section 8.4.1.2.2 for discussion on explosives found at reference locations.

TABLE 8-17. LITTLE GRAHAM CREEK SEDIMENT RESULTS

PARAMETER	UNIT	SE-04	Watershed Reference SE-11	SE-15	SE-20 **	Reference Average (SE-07-SE-12)	REGULATORY CRITERIA* SEDIMENT QUALITY BENCHMARK
Explosives and Degradates							
HMX	µg/g	0.050 U	0.050 U	0.050 U	0.050 U	0.092	0.330[1]
RDX	µg/g	**0.190**	**0.350**	**0.110**	**0.140**	0.545	0.190[1]
2,4,6-TNT	µg/g	**0.040**	**0.054**	**0.038**	**0.030**	0.117	0.52[1]
1,3-DNB	µg/g	0.020 U	0.020 U	0.020 U	0.020 U	0.020	0.04[1]
1,3,5-TNB	µg/g	0.020 U	0.020 U	0.020 U	0.020 U	0.020	0.02[1]
TETRYL	µg/g	0.020 U	0.020 U	0.020 U	0.020 U	0.020	NA
NB	µg/g	0.020 U	0.020 U	0.020 U	0.020 U	0.020	27.0[1]
2A-4,6-DNT	µg/g	0.020 U	0.020 U	0.020 U	0.020 U	0.020	NA
4A-2,6-DNT	µg/g	0.050 U	0.050 U	0.050 U	0.050 U	0.050	NA
2,6-DNT	µg/g	0.010 U	0.010 U	0.010 U	0.010 U	0.010	18.5[1]
2,4-DNT	µg/g	0.020 U	0.020 U	0.020 U	0.020 U	0.020	0.220[1]
2-NT	µg/g	0.020 U	0.020 U	0.020 U	0.020 U	0.020	NA
3-NT	µg/g	0.020 U	0.020 U	0.020 U	0.020 U	0.020	NA
4-NT	µg/g	0.070 U	0.070 U	0.060 U	0.070 U	0.063	NA
Nitroglycerin	µg/g	0.050 U	0.050 U	0.050 U	0.050 U	0.050	NA
WP	µg/g	0.0010 U	0.0010 U	0.0010 U	0.0010 U	0.001	
% Moisture (WP only)	Percent	20	20	18	20	19	
Metals							
Antimony	µg/g	**0.365**	**0.196**	**0.323**	**0.259**	0.244	NA
Arsenic	µg/g	**8.02**	**3.40 B**	**11.40**	**9.28**	5.78	5.9[2]
Barium	µg/g	**183**	**159**	**242**	**196**	206	NA
Cadmium	µg/g	**0.1330 B**	**0.0823 B**	**0.1770 B**	**0.0945 B**	0.0946	0.596[2]
Chromium	µg/g	**19.40**	**8.61**	**23.00**	**13.40**	11.27	26[3]
Copper	µg/g	**3.63**	**2.28**	**4.5**	**3.79**	4.18	16[3]
Lead	µg/g	**7.76**	**4.80**	**12.30**	**7.59**	7.84	31[3]
Manganese	µg/g	**391**	**143**	**392**	**325**	265	460[3]
Mercury	µg/g	**0.01740**	**0.01380**	**0.02390**	**0.01360**	0.01440	0.174[2]
Molybdenum	µg/g	**1.150**	**0.642**	**1.000**	**0.802**	0.741	NA
Nickel	µg/g	**8.27**	**2.42**	**6.71**	**4.42**	4.18	16[3]
Silver	µg/g	**0.1100**	**0.1460**	**0.1120**	**0.0606**	0.1017	1[4]
Uranium	µg/g	**0.516**	**0.416**	**0.666**	**0.504**	0.562	
Vanadium	µg/g	**35.4**	**27.3**	**35.1**	**20.8**	22.0	NA
Zinc	µg/g	**24.3**	**15.6**	**28.4**	**23.4**	18.8	120[3]
% Moisture	Percent	18.7	17.1	17.2	18.4	18.6	
Other Parameters							
Total Organic Matter	Percent	0.8	0.7	1.2	0.9	0.8	NA
Perchlorate	µg/g	0.012 U	0.013 U	0.012 U	0.012 U	0.013	NA
Benthic Macroinvertebrates							
Number of taxa		19	16	12	19	17	NA
Number of Individuals		276	351	233	276	148	NA
EPT/total individuals		46%	65%	35%	46%	49%	NA
Diversity H		2.84	2.23	2.42	2.84	2.63	NA

*-For complete citations see Table 8-3. **-SW-20 is a duplicate sample for SW-04. Underlining-represents results substantially above reference (above all reference values).
Bold-represents results above detection limit. **B**-represents parameter was also detected in laboratory blank for that run. **J**-estimate value below reporting limit. **NA**-not available.
U-under detection limit.

Highlighted represents exceedance of SQB

8.4.5.2.3 Perchlorate and TOM

Perchlorate was not detected in any Little Graham Creek sediment samples. The TOM is close to 1%, so the SQB does not need to be adjusted.

8.4.5.2.4 Sediment Quality Benchmarks

The Little Graham Creek sediment sample concentrations were compared to SQBs. The sediment sample results and the SQBs can be found in Table 8-17. Detected compounds exceeding their respective SQBs are highlighted in the table. One explosive compound (RDX) and one metal (arsenic) exceeded their respective benchmarks. The RDX benchmark of 0.190 µg/g was exceeded at the watershed reference sampling location (SE-11) with 0.350 µg/g RDX and the average reference value of 0.545 µg/g RDX. The downstream sampling location (SE-04) was right at the benchmark with 0.190 µg/g RDX. The arsenic benchmark of 5.9 µg/g was exceeded in the average of SE-04 and its duplicate (SE-20) with 8.65 µg/g and SE-15 with 11.40 µg/g arsenic. The conservative SQBs were only slightly exceeded, and chemistry data alone can only indicate that there is a possibility of an adverse impact on the ecological health. Benthic macroinvertebrate data were used to make the final determination.

8.4.5.3 Little Graham Creek Benthic Macroinvertebrate Results

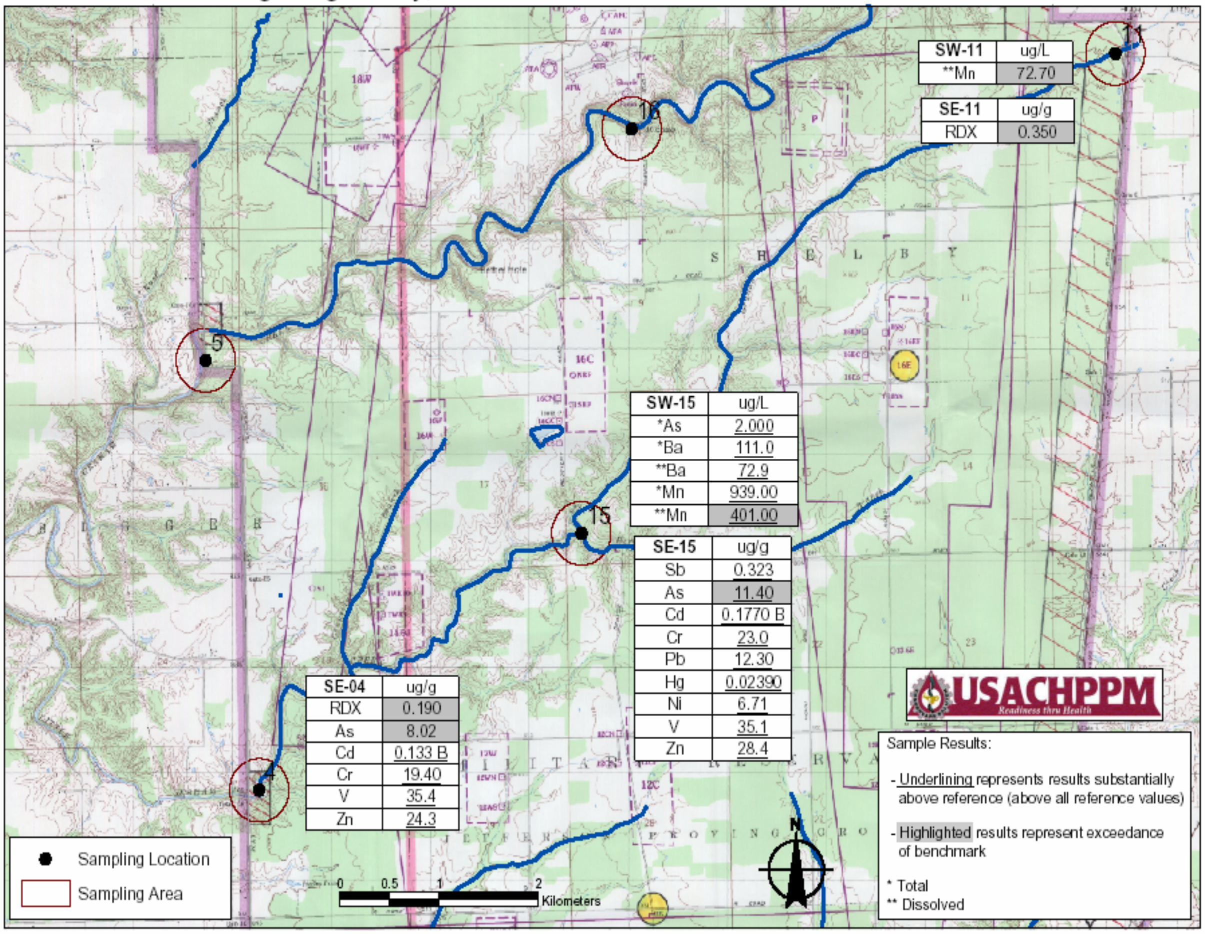
Little Graham Creek benthic macroinvertebrate results are presented in Table 8-17. There was some variability in the results but generally the benthic macroinvertebrate community was comparable and healthy at all sampling locations. The exceedance of RDX and arsenic benchmarks did not have an adverse impact on the biota.

8.4.5.4 Little Graham Creek Summary

Figure 8-4 shows the Little Graham Creek results exceeding benchmark or background values. Little Graham Creek conclusions are based on the one sampling event data collected during the field investigation. The data collected do not account for temporal variations and represent point estimates of exposure. The surface water results did not exceed Federal WQC or State WQSs at any of the sampling locations on Little Graham Creek and were not any higher than the average reference values at SW-04. Only total and dissolved arsenic, barium, and manganese were substantially higher than the average reference value at SW-15. The sediment results for Little Graham Creek exceeded the SQB for arsenic and RDX and was substantially higher than the average reference value for cadmium, chromium, vanadium, and zinc at SE-04 and antimony, arsenic, cadmium, chromium, lead, mercury, nickel, vanadium, and zinc at SE-15. There were no adverse impacts on the human health or the benthic macroinvertebrate ecology.

FIGURE 8-4 LITTLE GRAHAM CREEK WATERSHED RESULTS EXCEEDING BENCHMARK OR BACKGROUND VALUES

FIGURE 8-4. Little Graham Creek Watershed Results Exceeding Benchmark or Background Values, JPG Firing Range Study, 7-11 Oct. 2002



8.4.6 Graham Creek Watershed and Sampling Locations

This watershed is the next watershed to the north of Little Graham Creek. Water in the main channel flows southwest across the installation. Numerous impact areas are found in this watershed, both north and south of the main channel. Small tributaries capture drainage from these impact areas and funnel it into the main channel. Graham Creek drainage eventually flows off post to the southwest. Graham Creek sampling locations are shown in Figure 8-1. Graham Creek sampling location SW-10 is the upstream reference location. This sampling location is located on the eastern boundary of the post, in the main channel. Sampling location SW-16 is located in the middle of the installation around designated impact areas and just south of the Air National Guard active target area. Sample SW-19 is a duplicate of SW-16. SW-05 is the furthest downstream location sampled in Graham Creek. It captures drainage from all of the onpost part of Graham Creek. SW-21 is a split sample of SW-05.

8.4.6.1 Graham Creek Surface Water Results

Analytical results for all JPG surface water samples are presented in Table 8-5. The Federal WQC and State WQSs applicable to JPG surface waters are also included in this table for easy comparison. The Graham Creek surface water results, along with the reference for the Graham Creek watershed, and reference average for all sampled watersheds on JPG are presented in Table 8-18. The surface water results are discussed below.

8.4.6.1.1 Metals and Hardness

Both total and dissolved metal samples were collected. The Graham Creek surface water samples had moderate hardness values (156 to 175 mg/L), which are about the same as the reference average for all of JPG (160 mg/L).

In general, individual total metals concentrations exceeded their dissolved metals counterparts. Most metals were detected at low levels, some at or near the corresponding metal reporting limit.

There was no consistent pattern of metal concentrations in Graham Creek surface water samples. When taking into account the variability between the splits and duplicates (averaging splits and duplicates with their corresponding sample) and the average reference locations, the only substantial increase in the downstream locations was the total and dissolved arsenic and total mercury at sampling location SW-16 and its duplicate SW-19. There was a slight but insignificant increase in dissolved arsenic, total and dissolved silver, and total and dissolved vanadium in SW-05 and its split sample (SW-21) compared to the watershed reference (SW-10). Most metals decreased in concentration from upstream to downstream. The most decrease was at the furthest downstream location (SW-05). For arsenic, chromium, mercury, and vanadium, both total and dissolved concentrations increased slightly from the upstream reach (SW-10) to the middle of the installation (SW-16), and then decreased toward the downstream reach (SW-05). Other metals (barium, molybdenum, and uranium) showed a consistent slight decrease in concentration from the upstream reference location (SW-10) to the furthest downstream location (SW-05) in both total and dissolved form. Only one metal, silver, displayed a slight increase in both total and dissolved concentrations from the reference location (SW-10) through to the

TABLE 8-18. GRAHAM CREEK SURFACE WATER RESULTS

PARAMETER	UNIT	SW-5	Watershed Reference SW-10	SW-16	SW-19**	SW-21**	Reference Average (SW7-SW12)	REGULATORY CRITERIA* FEDERAL AMBIENT WATER QUALITY CRITERIA CMC	CCC	INDIANA AMBIENT WATER QUALITY CRITERIA CMC	CCC
Explosives and Degradates											
HMX	µg/L	3.0 U	3.0 U	3.0 U	3.0 U	3.0 U	3.0	NA	330	No numeric criteria have been established for these compounds.	
RDX	µg/L	**0.039 J**	**0.072 J**	**0.13**	**0.051 J**	**0.031 J**	0.062	4000	190		
2,4,6-TNT	µg/L	0.030 U	0.030 U	0.030 U	0.030 U	0.030 U	0.03	570	130		
1,3-DNB	µg/L	0.090 U	0.090 U	0.090 U	0.090 U	0.090 U	0.09	110	30		
1,3,5-TNB	µg/L	0.030 U	0.030 U	0.030 U	0.030 U	0.030 U	0.03	30	14		
TETRYL	µg/L	0.50 U	0.50 U	0.50 U	0.50 U	0.50 U	0.5	NA	NA		
NB	µg/L	0.030 U	0.030 U	0.030 U	0.030 U	0.030 U	0.03	27,000			
2A-4,6-DNT	µg/L	0.10 U	0.10 U	0.10 U	0.10 U	0.10 U	0.1	NA	NA		
4A-2,6-DNT	µg/L	0.10 U	0.10 U	0.10 U	0.10 U	0.10 U	0.1	NA	NA		
2,6-DNT	µg/L	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.01	18,500	NA		
2,4-DNT	µg/L	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.02	330	230		
2-NT	µg/L	0.090 U	0.090 U	0.090 U	0.090 U	0.090 U	0.09	NA	NA		
3-NT	µg/L	0.090 U	0.090 U	0.090 U	0.090 U	0.090 U	0.09	NA	NA		
4-NT	µg/L	0.090 U	0.090 U	0.090 U	0.090 U	0.090 U	0.09	NA	NA		
Nitroglycerin	µg/L	0.090 U	0.090 U	0.090 U	0.090 U	0.090 U	0.09	1700	200		
WP	µg/L	0.024 U	0.024 U	0.024 U	0.024 U	0.024 U	0.024	0.5	0.1		
Metals											
Hardness	mg/L	160	160	175	175	156	160	-	-	-	-
Antimony (Total/*Dissolved*)	µg/L	**0.0964** ***0.0993***	**0.1230** ***0.1110***	**0.1300** ***0.1010***	**0.1090** ***0.1150***	**0.0946** ***0.0967***	0.1036 0.0997	- 180	- 30	-	-
Arsenic	µg/L	**1.220** ***1.160***	**1.180** ***1.090***	**1.530** ***1.360***	**1.450** ***1.370***	**1.150** ***1.190***	0.983 1.027	- 340	- 150	360 -	190 -
Barium	µg/L	**52.3** ***52.8***	**58.4** ***58.1***	**57.0** ***53.4***	**54.7** ***53.7***	**52.2** ***51.4***	57.8 56.3	- 1000	1000	- -	- -
Cadmium	µg/L	**0.01380** ***0.01220***	**0.01700** ***0.08690***	**0.02310** ***0.01520***	**0.01460** ***0.01030***	**0.00875** ***0.01030***	0.04352 0.02993	- 4.3	- 2.2	4 -	1.1 -
Calcium	µg/L	**46600** ***46700***	**53400** ***45600***	**50900** ***50000***	**50500** ***49900***	**46000** ***45800***	47400 45950	- -	- -	- -	- -
Chromium	µg/L	**0.3110** ***0.2370***	**0.2980** ***0.3160***	**0.5750** ***0.3990***	**0.4540** ***0.3220***	**0.3180** ***0.2380***	0.4355 0.3898	- 570	- 74	1737 -	207 -
Copper	µg/L	**1.050** ***0.965***	**1.120** ***1.030***	**1.270** ***0.951***	**1.100** ***0.989***	**1.030** ***0.935***	1.066 1.030	- 13	- 9	18 -	9 -
Lead	µg/L	**0.10300** ***0.01920***	**0.07490** ***0.01300***	**0.37300** ***0.00500 U***	**0.14600** ***0.00500 U***	**0.08630** ***0.00936***	0.41493 0.05072	- 65	- 2.5	82 -	3 -
Magnesium	µg/L	**10200** ***10400***	**13500** ***11400***	**12400** ***12200***	**12300** ***12100***	**10200** ***10100***	11502 11025	- -	- -	- -	- -
Manganese	µg/L	**42.30** ***8.87***	**56.60** ***55.50***	**99.40** ***8.48***	**42.80** ***7.79***	**40.20** ***7.17***	56.58 39.48	- 50	- -	- -	- -
Mercury	µg/L	**0.002010** ***0.001310***	**0.001820** ***0.001350***	**0.00313** ***0.00163***	**0.00234** ***0.00148***	**0.00210** ***0.00138***	0.001783 0.001508	- 1.4	- 0.77	2.4 -	0.012 -
Molybdenum	µg/L	**0.994** ***0.980***	**1.330** ***1.310***	**1.160** ***1.200***	**1.210** ***1.230***	**0.991** ***0.963***	1.055 0.997	- 16000	- 370	- -	- -
Nickel	µg/L	**2.04** ***1.98***	**2.42** ***2.52***	**2.46** ***2.28***	**2.40** ***2.26***	**2.04** ***1.87***	2.20 2.29	- 470	- 52	1418 -	158 -
Silver	µg/L	**0.07600** ***0.09900***	**0.01010 B** ***0.00685 B***	**0.01990 B** ***0.00816 B***	**0.00928 B** ***0.00957 B***	**0.10500** ***0.12700***	0.05208 0.04755	- 3.4	- -	2 -	- -
Uranium	µg/L	**0.434** ***0.420***	**0.580** ***0.575***	**0.547** ***0.516***	**0.528** ***0.521***	**0.436** ***0.412***	0.717 0.697	- 46	- 2.6	- -	- -
Vanadium	µg/L	**0.822** ***0.672***	**0.739** ***0.622***	**1.220** ***0.801***	**1.010** ***0.813***	**0.807** ***0.661***	0.809 0.663	- 280	- 20	- -	- -
Zinc	µg/L	**0.802** ***0.596***	**1.010** ***4.410***	**1.590** ***2.400***	**0.941** ***0.605***	**0.658** ***0.517***	1.573 1.581	- 120	- 120	117 -	106 -
Other Parameters											
Perchlorate	µg/L	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0	5000	600	-	-
TOC	mg/L	8.2	7.0	**9.0**	**9.1**	**8.2**	6.1	-	-	-	-
pH (Field, Lab)	s.u.	7.91	7.69	8.07	8.07	7.91		6.5 - 9.0		-	
D.O. (Field)	mg/L	10.39	8.14	11.12	11.12	10.76		-	-	-	-
Conductivity (Field)	µ-ohm	355	407	400	400	355		-	-	-	-
Temperature (Field)	Deg. Cel.	13.75	14.2	13.36	13.36	13.69		-	-	-	-

*-For complete citations see Table 8-3. **-SW-19 is a duplicate sample for SW-16 and SW-21 is a split sample for SW-05. Underlining-represents results substantially above reference (above all reference values). **Bold**-represents results above detection limit. **B**-represents parameter was also detected in laboratory blank for that run. **J**-estimate value below reporting limit. **NA**-not available. **U**-under detection limit.

furthest downstream location (SW-05). However, this trend for silver has uncertainty because two of the samples for silver (at SW-10 and 16) have a "B" qualifier, indicating that silver was detected in the laboratory blank sample. Therefore, the trend for silver may not be accurate.

Overall, the metals data as a whole do not display any kind of a discernable pattern. There does not appear to be an association of increased metal concentrations with distance downstream. Therefore, it appears unlikely that firing range activities are contributing metals to the surface water of Graham Creek.

The Graham Creek surface water metal results (SW-05 and 16) were similar to the reference sampling location (SW-10) for the watershed and to the average reference locations for most metals (see Table 8-18).

8.4.6.1.2 Explosives and Degradates

RDX was detected in Graham Creek in the middle of the installation (sampling location SW-16) at a concentration of 0.13 µg/L. RDX was tenatively identified in all of the Graham Creek water samples to include the reference location. The values were presented with a J qualifier indicating that the value was an estimated concentration below the reporting limit. These values were not reportable but there was a good possibility that RDX was present. The estimated values for RDX were 0.039 µg/L, 0.072 µg/L, 0.051 µg/L, and 0.031µg/L for samples SW-05, SW-10, SW-16, and SW-21 respectively.

8.4.6.1.3 Perchlorate, TOC, and Field Parameters

Perchlorate was not detected in any Graham Creek samples. TOC ranged from 7.0 to 9.1 mg/L in Graham Creek surface water samples. The pH of the water was slightly alkaline, with values ranging from 7.69 to 8.07. Conductivity ranged from 355 to 407 µohm. The highest conductivity value (407 µohm) was found in the reference sample for Graham Creek (SW-10). Dissolved oxygen ranged from 8.14 to 11.12. TOC and the field parameters were well within reference values and what would be required to support a healthy ecological community.

8.4.6.1.4 Water Quality Criteria Screening

There were no parameters that exceeded the Federal WQC or State WQS in Graham Creek.

8.4.6.2 <u>Graham Creek Sediment Results</u>

Complete sediment analytical results, along with the SQBs, are presented in Table 8-6. Graham Creek sediment sample results along with the SQBs are included in Table 8-19 for easy comparison. Graham Creek sediment analytical sample results are discussed below.

8.4.6.2.1 Metals

There is no consistent pattern of metal concentrations in Graham Creek sediment. Because both downstream locations had either a duplicate or split sample there was variation within each sampling location. Therefore, the average of the sample and duplicate or split was used for

TABLE 8-19. GRAHAM CREEK SEDIMENT RESULTS

PARAMETER	UNIT	SE-5	SE-10	SE-16	SE-19**	SE-21**	Reference Average (SE7-SE12)	REGULATORY CRITERIA: SEDIMENT QUALITY BENCHMARK*
Explosives and Degradates								
HMX	µg/g	0.050 U	0.050 U	**0.320**	0.050 U	0.050 U	0.092	0.330[1]
RDX	µg/g	**0.120**	**0.220**	**1.100**	0.010 U	0.010 U	0.545	0.190[1]
2,4,6-TNT	µg/g	**0.020**	**0.034**	**0.130**	**0.018**	**0.007 J**	0.117	0.52[1]
1,3-DNB	µg/g	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020	0.04[1]
1,3,5-TNB	µg/g	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020	0.02[1]
TETRYL	µg/g	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020	NA
NB	µg/g	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020	27.0[1]
2A-4,6-DNT	µg/g	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020	NA
4A-2,6-DNT	µg/g	0.050 U	0.050 U	0.050 U	0.050 U	0.050 U	0.050	NA
2,6-DNT	µg/g	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010	18.5[1]
2,4-DNT	µg/g	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020	0.230[1]
2-NT	µg/g	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020	NA
3-NT	µg/g	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020	NA
4-NT	µg/g	0.050 U	0.060 U	0.060 U	0.050 U	0.020 U	0.063	NA
Nitroglycerin	µg/g	0.050 U	0.050 U	0.050 U	0.050 U	0.050 U	0.050	NA
WP	µg/g	0.0010 U	0.0010 U	0.0010 U	0.0010 U	0.0010 U	0.001	0.26[5]
Moisture (WP only)	Percent	15	22	20	20	17	19	NA
Metals								
Antimony	µg/g	**0.186**	**0.141**	**0.151**	**0.162**	**0.172**	0.244	NA
Arsenic	µg/g	**4.71 B**	**7.68**	**4.84 B**	**4.26 B**	**6.96**	5.78	5.9[2]
Barium	µg/g	**212**	**261**	**229**	**230**	**210**	206	500[3]
Cadmium	µg/g	**0.0669 B**	**0.0822 B**	**0.1060 B**	**0.1010 B**	0.0587 U	0.0946	0.596[2]
Chromium	µg/g	**11.40**	**9.40**	**11.5**	**18.5**	**12.6**	11.27	26[3]
Copper	µg/g	**2.37**	**8.20**	**3.86**	**3.43**	**3.14**	4.18	16[3]
Lead	µg/g	**6.03**	**7.85**	**7.36**	**7.64**	**8.52**	7.84	31[3]
Manganese	µg/g	**183**	**235**	**310**	**225**	**230**	265	460[3]
Mercury	µg/g	**0.01450**	**0.01020**	**0.00800 J**	**0.01030**	**0.00840 J**	0.01440	0.174[2]
Molybdenum	µg/g	**0.516**	**0.486**	**0.329**	**0.438**	**0.476**	0.741	NA
Nickel	µg/g	**3.34**	**4.06**	**3.04**	**3.32**	**3.38**	4.18	16[3]
Silver	µg/g	**0.0593**	**0.1060**	**0.0545**	**0.0846**	**0.0899**	0.1017	1[4]
Uranium	µg/g	**0.286**	**0.436**	**0.646**	**0.618**	**0.338**	0.562	NA
Vanadium	µg/g	**15.8**	**13.9**	**17.5**	**15.1**	**17.7**	22.0	NA
Zinc	µg/g	**18.6**	**16.0**	**22.8**	**20.1**	**19.7**	18.8	120[3]
Moisture	Percent	18.2	20.7	21.9	18.3	17.9	18.6	NA
Other Parameters								
Total Organic Matter	Percent	0.5	0.6	0.8	0.5	0.5	0.8	NA
Perchlorate	µg/g	0.013 U	0.013 U	0.013 U	0.013 U	0.013 U	0.013	NA
Benthic Macroinvertebrates								
Number of Taxa		20	21	16	NA	NA	17	NA
Number of individuals		407	205	160	NA	NA	148	NA
EPT/Total Individuals		30%	38%	23%	NA	NA	49%	NA
Diversity H		2.9	3.0	2.67	NA	NA	2.63	NA

*-For complete citations see Table 8-3. **-SE-19 is a duplicate sample for SE-16 and SE-21 is a split sample for SE-05. Underlining-represents results substantially above reference (above all reference values). **Bold**-represents results above detection limit. **B**-represents parameter was also detected in laboratory blank for that run. **J**-estimate value below reporting limit. **NA**-not available. **U**-under detection limit.

Highlighted represents exceedance of SQB

comparison to reference locations. None of the metals were substantially higher in the downstream locations compared to the average reference value. Six metals (arsenic, barium, copper, lead, nickel, and silver) all decreased in concentration from upstream (SE-10) to downstream locations (SE-05 and SE-16 and their respective duplicate SE-19 and split SE-21). Manganese and mercury were about equal in concentration from upstream to downstream. Cadmium, chromium, uranium, vanadium, and zinc all increased slightly at SE-16 and decreased from SE-16 to SE-05. Antimony and molybdenum were the only metals that continued to increase downstream. None of the metals increased by an order of magnitude or more from the upstream sampling location (SE-10) to the downstream sampling locations. Therefore, the metal levels present in Graham Creek sediment samples are likely due to naturally-occurring background metal concentrations with no more than a slight increase.

8.4.6.2.2 Explosives and Degradates

Of the 16 explosives and explosive degradates analyzed, only 3 (HMX, RDX, and 2,4,6-TNT) were detected in Graham Creek sediment samples (see Table 8-19). RDX and 2,4,6-TNT were detected in low concentrations in the reference sample (SE-10) and at the furthest downstream sample (SE-05). All three explosives were detected in the sample from the middle of the installation (SE-16).

Sample SE-19 was a duplicate for sample SE-16 and sample SE-21 was a split for sample SE-05. The results of the split and duplicate samples did not compare very well with the sample results. At sampling location SE-05, RDX and 2,4,6-TNT was detected at a concentration of 0.120 µg/g and 0.020 µg/g, respectively. Sample SE-21 was a split of sample SE-05. Sample SE-21 did not have detectable RDX in it, and the 2,4,6-TNT was reported at a concentration of 0.007 µg/g with a 'J' qualifier, indicating the concentration was an estimated value reported below the reporting limit. At sampling location SE-16, HMX, RDX, and 2,4,6-TNT were detected at concentrations of 0.320 µg/g, 1.100 µg/g, and 0.130 µg/g, respectively. Sample SE-19 was a duplicate of sample SE-16. Sample SE-19 did not have detectable HMX and RDX in it, and the detectable 2,4,6-TNT in it was at a concentration of 0.018 µg/g, which is just above the instrument detection limit of 0.010 µg/g. Because of the difference between duplicates, the RDX value at SE-05 and HMX, RDX, and 2,4,6-TNT values at SE-16 would be considered estimated values (see paragraph 8.5.2.1). RDX and 2,4,6-TNT were found in the reference location (SE-10) at concentrations of 0.220 µg/g and 0.034 µg/g, respectively.

8.4.6.2.3 Perchlorate and TOM

Perchlorate was not detected in any Graham Creek sediment samples. Total organic matter was slightly less than 1%, so the SQBs did not have to be adjusted.

8.4.6.2.4 Sediment Quality Benchmarks

The Graham Creek sediment sample concentrations were compared to SQBs. The sediment sample results and the SQBs can be found in Table 8-19. Detected compounds exceeding their respective SQBs are highlighted in Table 8-19. One explosive compound (RDX) and one metal (arsenic) exceeded their respective benchmarks. This situation is similar to the one in Little Graham Creek. Both RDX and arsenic exceeded their respective SQBs in Little Graham Creek.

TOM values for Graham Creek sediment samples are shown in Tables 8-6 and 8-19. Note that the TOM values (which range from 0.5 to 0.8%) are close to 1%. Therefore, the SQB values in Tables 8-6 and 8-19 (which assume 1% organic carbon) will be used for comparison.

Sample SE-10 had an RDX concentration of 0.220 µg/g. This concentration exceeded the RDX SQB of 0.190 µg/g. Sampling location SE-10 is the reference location for Graham Creek. As discussed previously, the detection of a military explosive compound (RDX) at this location is unexplained. The RDX value at SE-10 is less than two times the RDX SQB. There is a potential for RDX to adversely affect the stream ecology in the area around sampling location SE-10, but this potential is somewhat attenuated by the slight degree of exceedance. In the middle of the installation at sampling location SE-16, RDX sediment concentrations increase to 1.100 µg/g, which is substantially above the SQB of 0.190 µg/g. The duplicate for SE-16 (i.e., SE-19) showed no detectable RDX. Therefore, there is considerable uncertainty about the RDX detection in sample SE-16. Because of this uncertainty, the degree of SQB exceedance and/or detection of RDX in SE-16 is not known.

Sample SE-10 had an arsenic concentration of 7.68 µg/g. This concentration slightly exceeded the arsenic SQB of 5.9 µg/g. There is a potential for arsenic to adversely affect the stream ecology in the area around sampling location SE-10, but this potential is somewhat attenuated by the slight degree of exceedance. The detection of arsenic in SE-10 was considered reference because arsenic is a naturally occurring compound. However, chemistry data alone is insufficient to conclude adverse ecological health effects. Additional data (i.e., benthic macroinvertebrate results) was used to make this determination.

Split sample SE-21 had an arsenic concentration of 6.96 µg/g. This concentration slightly exceeded the arsenic SQB of 5.9 µg/g. The site sample for this split is SE-05. Sample SE-05 had an arsenic concentration of 4.71 µg/g, with a 'B' qualifier, indicating that arsenic was also detected in the laboratory blank sample. Therefore, there is uncertainty about the arsenic detection in sample SE-05. The detection may be the result of laboratory contamination. Because of this uncertainty, the degree of the SQB exceedance was not known. To determine whether arsenic was having an adverse effect on Graham Creek ecology, additional data (i.e., benthic macroinvertebrate results) was used.

8.4.6.3 Graham Creek Benthic Macroinvertebrate Results

The benthic macroinvertebrate results are presented in Table 8-7 and Graham Creek results are summarized in Table 8-19. The samples in Graham Creek were well within the variability seen between subsamples and between reference samples and all depict a healthy population. However, there is a subtle decrease in number of taxa, individuals, pollution intolerant individuals, and diversity at sampling location 16 compared to the watershed reference (10) but was the same as the average reference locations. The exceedance of the SQBs for RDX and arsenic at the watershed reference (10) had no adverse impact on the biota.

8.4.6.4 Graham Creek Summary

Figure 8-5 shows Graham Creek results exceeding benchmark or background values. Graham Creek conclusions are based on the one sampling event data collected during the field investigation. The data collected do not account for temporal variations and represent point estimates of exposure. The surface water results did not exceed Federal WQC or State WQSs and there were no substantially higher than the average reference values at the furthest downstream location SW-05. However, the midstream sampling location SW-16 was substantially higher in total and dissolved arsenic and total mercury than the average reference value. The sediment results for Graham Creek exceeded the SQB for arsenic and RDX at the watershed reference (SE-10) but the downstream locations were within SQBs when averaged with respective split and duplicate samples. HMX at sampling location SE-16 was the only sediment result substantially higher than average reference value. There were no adverse impacts on the human health or the benthic macroinvertebrate ecology.

8.4.7 Otter Creek Watershed and Sampling Locations

Some military activity occurs in this drainage basin, which is located in the extreme northern part of the post. Several impact areas can be found in the south-central part of this basin. The northeastern part of the basin contains Little Otter Dam; behind the dam is Old Timbers Lake. Three tributaries of Otter Creek originate off post to the north, flow to the south onto the post across the northern boundary, and then flow off post toward the west. The Otter Creek sampling locations appear in Figure 8-1. Otter Creek sampling locations SW-07, SW-08, and SW-09 served as upstream reference locations. Sampling locations SW-17 and SW-18 are located in the middle of the installation around designated impact areas. SW-17 is downstream of Little Otter Dam. It captures drainage from the dam and from Little Otter Fork tributary. SW-18 is downstream of the junction of the main channel and Little Otter Fork tributary. It captures drainage from the northern part of the post. Sampling location SW-06 is the furthest downstream location. This sampling location has water flowing through it from the entire watershed on post. Sample SW-22 is a split of SW-06.

8.4.7.1 Otter Creek Surface Water Results

Analytical results for all JPG surface water samples are summarized in Table 8-5. The Otter Creek surface water results, along with the average reference locations for JPG (SW-07-SW-12) and watershed average reference locations (SW-07-SW-09) are presented in Table 8-20. The Federal WQC and State WQSs applicable to JPG surface waters are also included in these tables for easy comparison. The Otter Creek surface water analytical sample results are discussed below.

8.4.7.1.1 Metals and Hardness

Both total and dissolved metal samples were collected. The Otter Creek surface water samples had moderate hardness values (range: 98 to 208 mg/L, mean: 153 mg/L), which is about the same as the reference average for all of JPG (160 mg/L).

FIGURE 8-5 GRAHAM CREEK WATERSHED RESULTS EXCEEDING BENCHMARK OR BACKGROUND VALUES

FIGURE 8-5. Graham Creek Watershed Results Exceeding Benchmark or Background Values, JPG Firing Range Study, 7-11 Oct. 2002

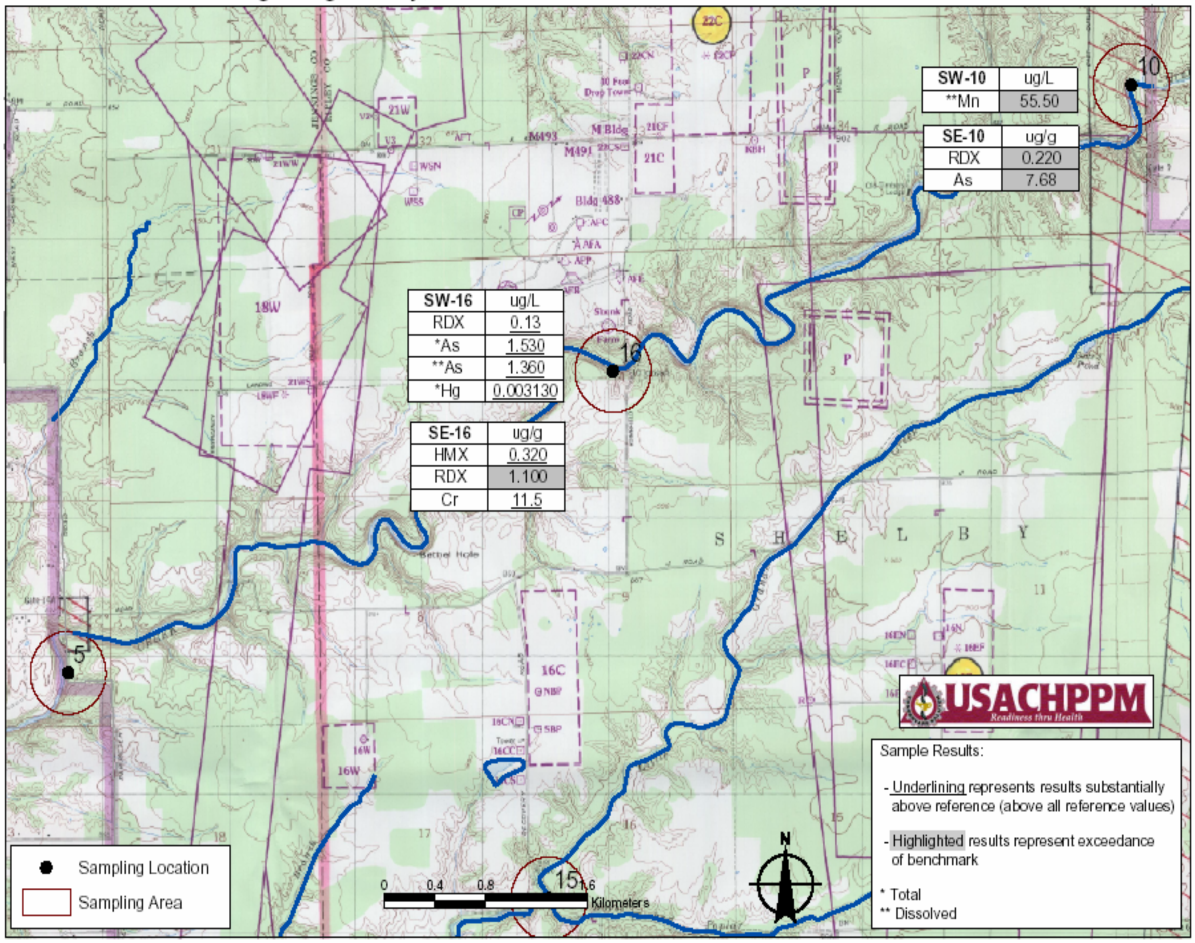


TABLE 8-20. OTTER CREEK SURFACE WATER RESULTS

PARAMETER	UNIT	SW-06	SW-07	SW-08	SW-09	Reference Average (SW-07-SW-09)	SW-17	SW-18	SW-22**	Reference Average (SW-7-SW-12)	REGULATORY CRITERIA* FEDERAL AMBIENT WATER QUALITY CRITERIA CMC	FEDERAL AMBIENT WATER QUALITY CRITERIA CCC	INDIANA AMBIENT WATER QUALITY CRITERIA CMC	INDIANA AMBIENT WATER QUALITY CRITERIA CCC
Explosives and Degradates														
HMX	μg/L	3..0U	3.0 U	3.0 U	3.0 U	3.0	3.0 U	3.0 U	3.0 U	3.0	NA	330	No numeric criteria have been established for these compounds.	
RDX	μg/L	0.100 U	0.100 U	0.100 U	**0.023 J**	0.062	0.100 U	0.100 U	**0.021 J**	0.062	4000	190		
2,4,6-TNT	μg/L	0.030 U	0.030 U	0.030 U	0.030 U	0.03	0.030 U	0.030 U	0.030 U	0.03	570	130		
1,3-DNB	μg/L	0.090 U	0.090 U	0.090 U	0.090 U	0.09	0.090 U	0.090 U	0.090 U	0.09	110	30		
1,3,5-TNB	μg/L	0.030 U	0.030 U	0.030 U	0.030 U	0.03	0.030 U	0.030 U	0.030 U	0.03	30	14		
TETRYL	μg/L	0.50 U	0.50 U	0.50 U	0.50 U	0.5	0.50 U	0.50 U	0.50 U	0.5	NA	NA		
NB	μg/L	0.030 U	0.030 U	0.030 U	0.030 U	0.03	0.030 U	0.030 U	0.030 U	0.03	27,000			
2A-4,6-DNT	μg/L	0.10 U	0.10 U	0.10 U	0.10 U	0.1	0.10 U	0.10 U	0.10 U	0.1	NA	NA		
4A-2,6-DNT	μg/L	0.10 U	0.10 U	0.10 U	0.10 U	0.1	0.10 U	0.10 U	0.10 U	0.1	NA	NA		
2,6-DNT	μg/L	0.010 U	0.010 U	0.010 U	0.010 U	0.01	0.010 U	0.010 U	0.010 U	0.01	18,500	NA		
2,4-DNT	μg/L	0.020 U	0.020 U	0.020 U	0.020 U	0.02	0.020 U	0.020 U	0.020 U	0.02	330	230		
2-NT	μg/L	0.090 U	0.090 U	0.090 U	0.090 U	0.09	0.090 U	0.090 U	0.090 U	0.09	NA	NA		
3-NT	μg/L	0.090 U	0.090 U	0.090 U	0.090 U	0.09	0.090 U	0.090 U	0.090 U	0.09	NA	NA		
4-NT	μg/L	0.090 U	0.090 U	0.090 U	0.090 U	0.09	0.090 U	0.090 U	0.090 U	0.09	NA	NA		
Nitroglycerin	μg/L	0.090 U	0.090 U	0.090 U	0.090 U	0.09	0.090 U	0.090 U	0.090 U	0.09	1700	200		
WP	μg/L	0.024 U	0.024 U	0.024 U	0.024 U	0.024	0.024 U	0.024 U	0.024 U	0.024	0.5	0.1		
Metals														
Hardness	mg/L	149	172	208	156	178	98	144	148	160	-	-	-	-
Antimony (Total/*Dissolved*)	μg/L	**0.0814** *0.0856*	**0.0924** *0.0913*	**0.0734** *0.0651*	**0.0957** *0.0886*	**0.0871** *0.0816*	**0.0611** *0.0616*	**0.0733** *0.0711*	**0.0781** *0.0793*	0.1036 0.0997	- 180	- 30	-	-
Arsenic	μg/L	**0.914** *0.989*	**1.160** *1.290*	**0.808** *0.896*	**0.917** *1.150*	**0.961** *1.112*	**0.773** *0.791*	**0.839** *0.906*	**0.900** *1.040*	0.983 1.027	- 340	- 150	360 -	190 -
Barium	μg/L	**45.0** *45.0*	**52.9** *51.2*	**58.2** *57.3*	**65.3** *62.6*	**58.8** *57.0*	**37.4** *34.9*	**44.9** *42.7*	**45.9** *44.2*	57.8 56.3	- 1000	1000	- -	- -
Cadmium	μg/L	**0.01140** *0.00670*	**0.00963** *0.01040*	**0.06130** *0.02530*	**0.13600** *0.01880*	**0.0689** *0.0181*	**0.00790** *0.01070*	**0.01190** *0.01020*	**0.01020** *0.00709*	0.04352 0.02993	- 4.3	- 2.2	4 -	1.1 -
Calcium	μg/L	**46400** *46300*	**51900** *51800*	**57100** *57100*	**44800** *44300*	**51266** *51066*	**30000** *30300*	**45300** *44500*	**46200** *45800*	47400 45950	- -	- -	- -	- -
Chromium	μg/L	**0.3110** *0.2100*	**0.4080** *0.3940*	**0.5220** *0.8110*	**0.2920** *0.4030*	**0.407** *0.536*	**0.3430** *0.2500*	**0.2320** *0.2740*	**0.3090** *0.2940*	0.4355 0.3898	- 570	- 74	1737 -	207 -
Copper	μg/L	**0.864** *0.871*	**0.989** *0.968*	**0.614** *0.600*	**1.180** *1.180*	**0.927** *0.916*	**0.549** *0.526*	**0.811** *0.780*	**0.846** *0.943*	1.066 1.030	- 13	- 9	18 -	9 -
Lead	μg/L	**0.07200** *0.00935*	**0.05780** *0.01890*	**0.07110** *0.00830*	**0.04080** *0.00500 U*	**0.0565** *0.0107*	**0.18800** *0.03220*	**0.07320** *0.01730*	**0.05620** *0.01530*	0.41493 0.05072	- 65	- 2.5	82 -	3 -
Magnesium	μg/L	**8000** *8170*	**10300** *10300*	**16400** *15800*	**11200** *11000*	**12633** *12366*	**5340** *5460*	**7950** *7920*	**7990** *8160*	11502 11025	- -	- -	- -	- -
Manganese	μg/L	**50.60** *50.70*	**27.70** *11.40*	**50.10** *39.70*	**78.80** *22.70*	**52.2** *24.6*	**37.10** *20.20*	**57.70** *42.10*	**54.00** *22.90*	56.58 39.48	- 50	- -	- -	- -
Mercury	μg/L	**0.001600** *0.001200*	**0.001700** *0.001330*	**0.000890** *0.000860*	**0.002280** *0.002020*	**0.00162** *0.00140*	**0.00181** *0.00151*	**0.00157** *0.00132*	**0.00159** *0.00127*	0.001783 0.001508	- 1.4	- 0.77	2.4 -	0.012 -
Molybdenum	μg/L	**0.745** *0.683*	**0.928** *0.861*	**1.070** *1.020*	**1.650** *1.380*	**1.21** *1.087*	**0.455** *0.454*	**0.661** *0.621*	**0.749** *0.714*	1.055 0.997	- 16000	- 370	- -	- -
Nickel	μg/L	**2.04** *2.19*	**2.23** *2.48*	**2.43** *2.44*	**2.33** *2.35*	**2.33** *2.42*	**1.51** *1.46*	**2.02** *2.01*	**2.04** *2.35*	2.20 2.29	- 470	- 52	1418 -	158 -
Silver	μg/L	**0.01280 B** *0.01410 B*	**0.01220 B** *0.00400 U*	**0.04300 B** *0.00401 B*	**0.01860 B** *0.00400 U*	**0.0246** *0.0040*	**0.01670 B** *0.02160 B*	**0.01370 B** *0.01810 B*	**0.01150 B** *0.00526 B*	0.05208 0.04755	- 3.4	- -	2 -	- -
Uranium	μg/L	**0.379** *0.374*	**0.510** *0.483*	**0.796** *0.779*	**1.110** *1.040*	**0.805** *0.767*	**0.174** *0.161*	**0.344** *0.325*	**0.388** *0.371*	0.717 0.697	- 46	- 2.6	- -	- -
Vanadium	μg/L	**0.629** *0.526*	**0.707** *0.632*	**0.562** *0.485*	**0.629** *0.567*	**0.632** *0.561*	**0.588** *0.328*	**0.546** *0.446*	**0.625** *0.523*	0.809 0.663	- 280	- 20	- -	- -
Zinc	μg/L	**1.250** *0.216*	**1.180** *0.702*	**2.180** *1.210*	**1.870** *1.020*	**1.743** *0.977*	**1.020** *0.455*	**1.580** *0.287*	**0.588** *0.475*	1.573 1.581	- 120	- 120	117 -	106 -
Other Parameters														
Perchlorate	μg/L	1.0 U	1.0 U	1.0 U	1.0 U	1.0	1.0 U	1.0 U	1.0 U	1.0	5000	600	-	-
TOC	mg/L	5.9	6.5	3.2	8.3	**60**	**7.0**	**5.4**	**5.8**	6.1	-	-	-	-
pH (Field)	s.u.	8.12	8.17	7.55	7.15	NA	8.14	7.95	8.12	NA	6.5 - 9.0		-	
D.O. (Field)	mg/L	2.17	11.24	10.51	7.37	NA	7.1	2.41	2.17	NA	-	-	-	-
Conductivity (Field)	μ-ohm	262	319	369	271	NA	170	257	262	NA	-	-	-	-
Temperature (Field)	Deg.Cel	16.9	16.55	15.68	15.38	NA	16.34	16.15	16.9	NA	-	-	-	-

*-For complete citations see Table 8-3. **-SW-22 is a split sample for SW-06. Underlining-represents results substantially above reference (above all reference values).
Bold-represents results above detection limit. **B**-represents parameter was also detected in laboratory blank for that run. **J**-estimate value below reporting limit. **NA**-not available.
U-under detection limit.

In general, individual total metals concentrations exceeded their dissolved metals counterparts. However, a number of metals (antimony, arsenic, cadmium, calcium, chromium, copper, magnesium, manganese, nickel, and silver) had one or more total metal concentrations below their dissolved counterparts (see Table 8-20). Most metals were detected at low levels, some at or near the corresponding metal reporting limit.

The Otter Creek watershed had three reference sampling locations along the northern boundary of the installation. They were (from west to east) sampling locations SW-07, SW-08, and SW-09. In order to evaluate upstream-downstream trends in metal concentrations, the values from individual metals at these three sampling locations were averaged to provide one Otter Creek watershed reference value for comparison purposes. Where nondetect values were encountered, the detection limit was used. In addition to the Otter Creek watershed reference values, sample results were also compared to the reference average for all of JPG.

There was no consistent pattern of metal concentrations in Otter Creek surface water samples. If SW-06 and its split SW-22 are averaged before comparing downstream samples to references, all the following metals were lower in the downstream sampling sites (total: calcium, nickel, and silver) (total and dissolved: antimony, arsenic, barium, cadmium, chromium, copper, magnesium, molybdenum, uranium, vanadium, and zinc). There were no metals substantially higher than reference values. Dissolved silver, dissolved lead, and dissolved manganese were slightly higher at the downstream sampling locations.

- Dissolved silver increased at SW-06, SW-17, and SW-18 with values of 0.0141 µg/L, 0.0216 µg/L, and 0.0181 µg/L respectively compared to 0.0040 µg/L for the watershed average reference. However, the field and laboratory blanks averaged 0.0153 µg/L and 0.0141 µg/L respectively. Therefore, the detection of silver near these concentrations has uncertainty attached to it.
- Dissolved lead values at SW-17, SW-18, SW-06, and SW-22 were 0.0322 µg/L, 0.0173 µg/L, 0.00935µg/L, and 0.0153 µg/L (0.0123 µg/L for SW- 06 and SW-22 average) respectively compared to 0.0107 µg/L and 0.0507µg/L for the Otter Creek reference average and the JPG reference average respectively.
- Dissolved manganese at SW-06 was 50.7 µg/L and its split sample SW-22 was 22.9 µg/L compared to a watershed average of 24.6µg/L and JPG average reference of 39.48 µg/L. The variability between the sample and the split make the downstream increase questionable.

Overall, the metals data as a whole do not display any kind of a consistent pattern. There does not appear to be an association of increased metal concentrations with distance downstream. Therefore, it appears unlikely that firing range activities are contributing metals to the surface water of Otter Creek.

In general, the Otter Creek surface water metal results were similar to the Otter Creek reference average and to the JPG reference average concentrations for most metals (see Table 8-20).

8.4.7.1.2 Explosives and Degradates

No explosives were detected at the reporting limit in Otter Creek surface water samples. RDX was detected below the reporting limit at the reference location (SW-09) at an estimated concentration of 0.023 µg/L (see Table 8-20). As noted previously, explosives detections at reference locations are unexpected. At this time, no known explanation exists for this detection. RDX was also detected below the reporting limit at the furthest downstream location in a split sample (SW-22) at an estimated concentration of 0.021 µg/L (see Table 8-18). The reporting limit for both samples were 0.100 µg/L RDX.

8.4.7.1.3 Perchlorate, TOC, and Field Parameters

Perchlorate was not detected above the reporting limit in any Otter Creek sample. Sample SW-07 had an estimated perchlorate concentration of 0.87 µg/L with a reporting limit of 1.0 µg/L. This is the only detection of perchlorate in JPG surface water sampled during this study. It is an outlier detection. TOC ranged from 3.2 to 8.3 mg/L in Otter Creek surface water samples. The pH of the water was slightly alkaline, with values ranging from 7.15 to 8.17. The alkalinity is most likely due to the surface water flowing over limestone terrain. Conductivity ranged from 170 to 369 µohm. The highest conductivity value (369 µohm) was found in one of the reference samples for Otter Creek (SW-08). Dissolved oxygen ranged from 2.17 to 11.24. The TOC and field values were all within the range that could support a healthy ecological community.

8.4.7.1.4 Water Quality Criteria Screening

No parameters exceeded water quality criteria in Otter Creek surface water samples.

8.4.7.2 Otter Creek Sediment Results

Sediment analytical results for all sediment sampling at JPG are presented in Table 8-6 and results for Otter Creek are presented in Table 8-21. The SQBs are also presented for easy comparison. Otter Creek sediment analytical sample results are discussed below.

8.4.7.2.1 Metals

Metals were detected at low levels in almost all Otter Creek sediment samples. The metals that substantially increased in the downstream locations compared to the reference locations were arsenic in samples SE-06 and SE-18, barium in SE-06 and SE-17, chromium in SE-17, copper in SE-17, mercury at SE-17 and SE-18, and zinc in SE-06, SE-17 and SE-18 (see Table 8-21). Most of the metals (antimony, barium, chromium, copper, lead, manganese, nickel, silver, uranium, vanadium, and zinc) concentrations increased from the upstream sampling locations, Otter Creek average reference, and JPG average reference values to the middle of the installation (SE-17), and then decreased toward the downstream reach (SE-18), and then increased again toward the furthest downstream sampling location at the installation western boundary (SE-06) (see Table 8-21). One metal (arsenic) showed a pattern of increasing metal concentrations in downstream Otter Creek samples from upstream reference locations to downstream sampling locations, indicating possible onpost accumulation of this metal. The remaining metals showed

TABLE 8-21. OTTER CREEK SEDIMENT RESULTS

PARAMETER	UNIT	SE-06	SE-07	SE-08	SE-09	Watershed Reference Average (SE-07-SE-09)	SE-17	SE-18	SE-22**	JPG Reference Average (SE-07 -SE-12)	REGULATORY CRITERIA SEDIMENT QUALITY BENCHMARK*
Explosives and Degradates											
HMX	µg/g	**0.080**	**0.091**	**0.260**	0.050 U	0.134	**0.04 J**	0.050 U	**0.046 J**	0.092	0.330[1]
RDX	µg/g	**0.260**	**0.420**	**1.900**	**0.098**	0.806	**0.260**	**0.120**	**0.250**	0.545	0.190[1]
2,4,6-TNT	µg/g	**0.046**	**0.086**	**0.280**	**0.200**	0.189	**0.043**	**0.016**	**0.040**	0.117	0.52[1]
1,3-DNB	µg/g	0.020 U	0.020 U	0.020 U	0.020 U	0.020	0.020 U	0.020 U	0.020 U	0.020	0.04[1]
1,3,5-TNB	µg/g	0.020 U	0.020 U	0.020 U	0.020 U	0.020	0.020 U	0.020 U	0.020 U	0.020	0.02[1]
TETRYL	µg/g	0.020 U	0.020 U	0.020 U	0.020 U	0.020	0.020 U	0.020 U	0.020 U	0.020	NA
NB	µg/g	0.020 U	0.020 U	0.020 U	0.020 U	0.020	0.020 U	0.020 U	0.020 U	0.020	27.0[1]
2A-4,6-DNT	µg/g	0.020 U	0.020 U	0.020 U	0.020 U	0.020	0.020 U	0.020 U	0.020 U	0.020	NA
4A-2,6-DNT	µg/g	0.050 U	0.050 U	0.050 U	0.050 U	0.050	0.050 U	0.050 U	0.050 U	0.050	NA
2,6-DNT	µg/g	0.010 U	0.010 U	0.010 U	0.010 U	0.010	0.010 U	0.010 U	0.010 U	0.010	18.5[1]
2,4-DNT	µg/g	0.020 U	0.020 U	0.020 U	0.020 U	0.020	0.020 U	0.020 U	0.020 U	0.020	0.230[1]
2-NT	µg/g	0.020 U	0.020 U	0.020 U	0.020 U	0.020	0.020 U	0.020 U	0.020 U	0.020	NA
3-NT	µg/g	0.020 U	0.020 U	0.020 U	0.020 U	0.020	0.020 U	0.020 U	0.020 U	0.020	NA
4-NT	µg/g	0.080 U	0.070 U	0.070 U	0.050 U	0.063	0.070 U	0.050 U	0.070 U	0.063	NA
Nitroglycerin	µg/g	0.050 U	0.050 U	0.050 U	0.050 U	0.050	0.050 U	0.050 U	0.050 U	0.050	NA
WP	µg/g	0.0010 U	0.0010 U	0.0010 U	0.0010 U	0.001	0.0010 U	0.0010 U	0.0010 U	0.001	0.26[5]
Moisture (WP only)	µg/g	19	21	11	18		21	22	18	19	NA
Metals											
Antimony	µg/g	**0.253**	**0.271**	**0.348**	**0.195**	**.0271**	**0.280**	**0.217**	**0.343**	0.244	NA
Arsenic	µg/g	**20.20**	**3.79 B**	**6.45**	**3.70 B**	**4.64**	**5.52 B**	**15.90**	**18.70**	5.78	5.9[2]
Barium	µg/g	**318**	**246**	**180**	**243**	**223**	**249**	**219**	**287**	206	500[3]
Cadmium	µg/g	0.0587 U	**0.103 B**	**0.0955 B**	**0.0964 B**	**0.0983**	**0.1580 B**	0.0587 U	0.0587 U	0.0946	0.596[2]
Chromium	µg/g	**18.20**	**17.50**	**11.90**	**7.53**	**12.31**	**19.6**	**14.2**	**33.6**	11.27	26[3]
Copper	µg/g	**3.59**	**3.07**	**4.61**	**3.85**	**3.84**	**5.95**	**2.11**	**3.59**	4.18	16[3]
Lead	µg/g	**10.50**	**6.84**	**11.50**	**7.03**	**8.45**	**10.90**	**6.72**	**10.20**	7.84	31[3]
Manganese	µg/g	**326**	**154**	**496**	**237**	**295.6**	**434**	**219**	**298**	265	460[3]
Mercury	µg/g	**0.00710 B,J**	**0.01350 B**	**0.01600 B**	**0.01910 B**	**0.0162**	**0.02030**	**0.02120 B**	**0.01160 B**	0.01440	0.174[2]
Molybdenum	µg/g	**0.868**	**0.837**	**1.150**	**0.452**	**0.813**	**0.606**	**0.554**	**0.897**	0.741	NA
Nickel	µg/g	**5.73**	**5.24**	**6.61**	**3.08**	**4.97**	**5.86**	**4.53**	**5.72**	4.18	16[3]
Silver	µg/g	**0.0803**	**0.0729**	**0.1350**	**0.0485**	**0.0854**	**0.0985**	**0.0592**	**0.0625**	0.1017	1[4]
Uranium	µg/g	**0.719**	**0.357**	**0.948**	**0.682**	**0.662**	**0.964**	**0.462**	**0.755**	0.562	NA
Vanadium	µg/g	**25.8**	**21.7**	**25.5**	**16.1**	**21.1**	**26.8**	**23.0**	**26.4**	22.0	NA
Zinc	µg/g	**44.6**	**16.7**	**23.8**	**19.2**	**19.9**	**35.2**	**31.6**	**42.5**	18.8	120[3]
Moisture	Percent	20.1	20.7	12.0	20.8	17.8	26.8	20.6	20.7	18.6	NA
Other Parameters											
Total Organic Matter	Percent	0.9	0.6	1.6	0.6	0.9	1.7	0.4	0.9	0.8	NA
Perchlorate	µg/g	0.013 U	0.013 U	0.011 U	0.013 U	0.013	0.012 U	0.013 U	0.012 U	0.013	NA
Benthic Macroinvertebrates											
Number of Taxa		15	20	16	10	15	20	17	NA	17	NA
Number of Individuals		97	91	88	18	67	114	160	NA	148	NA
EPT/total individuals		55%	49%	73%	11%	44%	57%	90%	NA	49%	NA
Diversity H		2.86	3.12	2.84	2.28	2.75	2.79	3.72	NA	2.63	NA

*-For complete citations see Table 8-3. **-SE-22 is a split sample for SE-06. Underlining-represents results substantially above reference (above all reference values).
Bold-represents results above detection limit. **B**-represents parameter was also detected in laboratory blank for that run. **J**-estimate value below reporting limit. **NA**-not available.
U-under detection limit.

Highlighted represents exceedance of SQB

no definite trend whatsoever. The metals levels present in Otter Creek sediment samples showed a more pronounced trend toward increasing metals in downstream locations than in the other watersheds.

8.4.7.2.2 Explosives and Degradates

Of the 16 explosives and explosive degradates analyzed, only three (HMX, RDX, and 2,4,6-TNT) were detected in Otter Creek sediment samples (see Table 8-21). All three of these explosive compounds were detected in low concentrations in the reference samples (SE-07 and SE-08), and two explosives (RDX and 2,4,6-TNT) were detected in the third reference sample (SE-09). All three of these explosive compounds were detected in the middle of the installation at sampling location SE-17, and two explosives were detected at SE-18. In addition, all three explosives were detected at the furthest downstream sample (SE-06).

In order to evaluate upstream-downstream trends in explosive concentrations, the detected values from individual samples at the three reference sampling locations along the northern boundary (SE-07, SE-08, and SE-09) were averaged. This provided one Otter Creek watershed reference value for comparison purposes (see Table 8-21). Where nondetect values were encountered, the detection limit was used.

RDX and 2,4,6-TNT were found in all three reference locations for Otter Creek (SE-07, SE-08, and SE-09) (see Table 8-21). RDX values in samples SE-07, SE-08, and SE-09 are 0.420, 1.900, and 0.098 μg/g, with an average of 0.806 μg/g; 2,4,6-TNT values are 0.086, 0.280, and 0.200 μg/g, with an average of 0.188 μg/g. These compounds and concentrations are surprizingly similar to what was found at sampling locations SE-10 and SE-11, the reference locations for Graham Creek and Little Graham Creek, respectively. In addition, HMX was detected in samples SE-07 and SE-08 in concentrations of 0.091 μg/g and 0.260 μg/g, respectively. HMX was not detected in sample SE-09, and also was not detected in the reference locations for Graham Creek and Little Graham Creek. Explosives detections at reference locations are clearly unexpected.

In the sample average of SE-06 and its split (SE-22) HMX, RDX, and 2,4,6-TNT were detected at concentrations of 0.062 μg/g, 0.255 μg/g, and 0.043 μg/g, respectively. The sample and split results compared fairly well so the detected concentrations were considered reliable. The sediment results for HMX, RDX, and 2,4,6-TNT in sample SE-06 were lower than the reference averages.

RDX and 2,4,6-TNT were found in the middle of the installation (in samples SE-17 and SE-18) at concentrations of 0.260 μg/g, and 0.043 μg/g, and 0.120 μg/g, and 0.016 μg/g respectively. The sediment results for RDX and 2,4,6-TNT in samples SE-17 and SE-18 were lower than the reference averages.

8.4.7.2.3 Perchlorate and TOM

Perchlorate was not detected in any Otter Creek sediment samples. Total organic matter was less than 1% on an average. Therefore, the calculation of the SQBs does not need to be adjusted.

8.4.7.2.4 Sediment Quality Benchmarks

The Otter Creek sediment sample concentrations were compared to SQBs. Detected compounds that exceeded their respective SQBs are highlighted in Table 8-21. One explosive compound (RDX) and two metals (arsenic and manganese) exceeded their respective benchmarks.

TOM values for Otter Creek sediment samples are shown in Tables 8-21. TOM values (range: 0.4 -1.7%, average: 0.95%) are close to 1%. Therefore, the SQB values in Tables 8-21 (which assume 1% organic carbon) will be used for comparison.

Samples SE-07 and SE-08 had RDX concentrations of 0.420 µg/g and 1.900 µg/g, respectively. These concentrations exceeded the RDX SQB of 0.190 µg/g. Sampling location SE-08 had an arsenic concentration of 6.45 µg/g, which exceeded the arsenic SQB of 5.9 µg/g. This sampling location also had a manganese concentration of 496 µg/g which exceeded the manganese SQB of 460 µg/g. Both arsenic and manganese exceed their respective SQBs by less than a factor of two. Sampling locations SE-07 and SE-08 are reference locations for Otter Creek. As discussed previously, the detection of a military explosive compound (RDX) at a reference location is unexplained. The RDX value in SE-07 is about two times the RDX SQB. However, the RDX value at SE-08 was ten times the RDX SQB. There was a potential for RDX, arsenic, and manganese to adversely affect stream ecology in the area around sampling locations 07 and 08, but the potential at sampling location SE-07 was somewhat attenuated by the slight degree of exceedance of the SQB. The potential for adverse affects at sampling location SE-08 was higher than at sampling location SE-07, due mainly to the higher RDX concentration. Nevertheless, sediment chemistry alone was insufficient to conclude adverse ecological effects. Chemistry data indicated a *potential* for ecological health effects. To determine if an actual ecological health effect had occurred biological data from the benthic macroinvertebrates was evaluated and no adverse impact was found (See paragraph 8.4.7.3).

In the middle of the installation in samples SE-17 and SE-18, arsenic and RDX exceeded the SQB. The RDX sediment concentration in SE-17 was 0.260 µg/g, which was slightly above the RDX SQB of 0.190 µg/g. The arsenic sediment concentration in sample SE-18 was 15.90 µg/g, which was above the arsenic SQB of 5.9 µg/g. Again, there was a *potential* for ecological health effects but benthic macroinvertebrate data was evaluated and no adverse impact was found (See paragraph 8.4.7.3).

Finally, as Otter Creek exits JPG and flows west (sampling location 06), RDX and arsenic were found in the sediment above their respective SQBs (see Table 8-21). Split sample SE-22 had remarkably similar values to SE-06. The RDX values in samples SE-06 and split SE-22 were 0.260 µg/g and 0.250 µg/g, respectively. Arsenic was 20.20 µg/g and 18.70 µg/g in samples SE-06 and split SE-22, respectively. This similarity lends credence to the presence and concentration values of the detected RDX and arsenic at sampling location SE-06. There was a *potential* for RDX and arsenic to adversely affect the stream ecology in the area around sampling location SE-06. To determine if an actual ecological health effect had occurred biological data from the benthic macroinvertebrates was evaluated and no adverse impact was found (See paragraph 8.4.7.3).

8.4.7.3 Otter Creek Benthic Macroinvertebrate Results

The complete benthic macroinvertebrate results are presented Table 8-7 and Otter Creek summary of results is presented in Table 8-21. The samples in Otter Creek were well within the variability seen between subsamples and between reference samples. All depict a healthy population. However, there is a subtle increase in the health of the benthic macroinvertebrate population seen in some of the metrics as compared to the watershed reference average. The difference indicates that water quality and the corresponding ecological community was not being adversely affected by the explosives compounds or firing range activity. The slightly better benthic macroinvertebrate metrics could be due to forested and protected watersheds, and the increase in stream size (order).

8.4.7.4 Otter Creek Summary

Figure 8-6 shows Otter Creek results exceeding benchmark or background values. Otter Creek conclusions are based on the one sampling event data collected during the field investigation. The data collected do not account for temporal variations and represent point estimates of exposure. The surface water results for Otter Creek did not exceed Federal WQC or State WQSs, and there were no results that were substantially higher than the average reference values. The sediment results for Otter Creek exceeded the SQB for arsenic at sampling locations SE-06, SE-08, and SE-18, and RDX at sampling locations SE-06, SE-07, SE-08, and SE-17. The only sediment results that were substantially higher than both average reference values were arsenic at SE-06 and SE-18, barium at SE-17, cadmium at SE-17, chromium at SE-06 and SE-17, copper at SE-17, mercury at SE-17 and SE-18, and zinc at SE-06, SE-17, and SE-18. HMX, RDX, and 2,4,6-TNT were detected in the sediments at several sampling locations (both reference and downstream). However, there were no adverse impacts on the benthic macroinvertebrate ecology.

8.4.8 Seep (Spring) Sampling Locations

There were three seeps (springs) identified as possible sampling locations during the scoping visit. The drought conditions caused two of the seeps to totally dry up. The third location had a very low flow (about 1/10th of a gallon per minute). The water from this seep was sampled to determine if undiluted ground water would meet Federal WQC and State WQSs. The seep was originating close to the northwest bank of Middle Fork Creek about 200 yards downstream of Jimestown Road near the western boundary of JPG. There were few activities upslope from the seep. There was an impact field across Jimestown Road but the majority of the watershed for the seep was in the buffer zone near the west boundary. There was a stone springhouse built around the seep. The sampling location was identified as GS-01 for ground-water seep.

8.4.8.1 Seep Sample Water Quality Results

The water quality results are presented in Table 8-5. The seep sample GS-01 water quality results, along with the average reference locations for JPG (SW-07-SW-12) are presented in Table 8-22. The Federal WQC and State WQSs applicable to JPG surface waters are also included in these tables for easy comparison. The seep sample water quality analytical sample results are discussed below.

FIGURE 8-6 OTTER CREEK WATERSHED RESULTS EXCEEDING BENCHMARK OR BACKGROUND VALUES

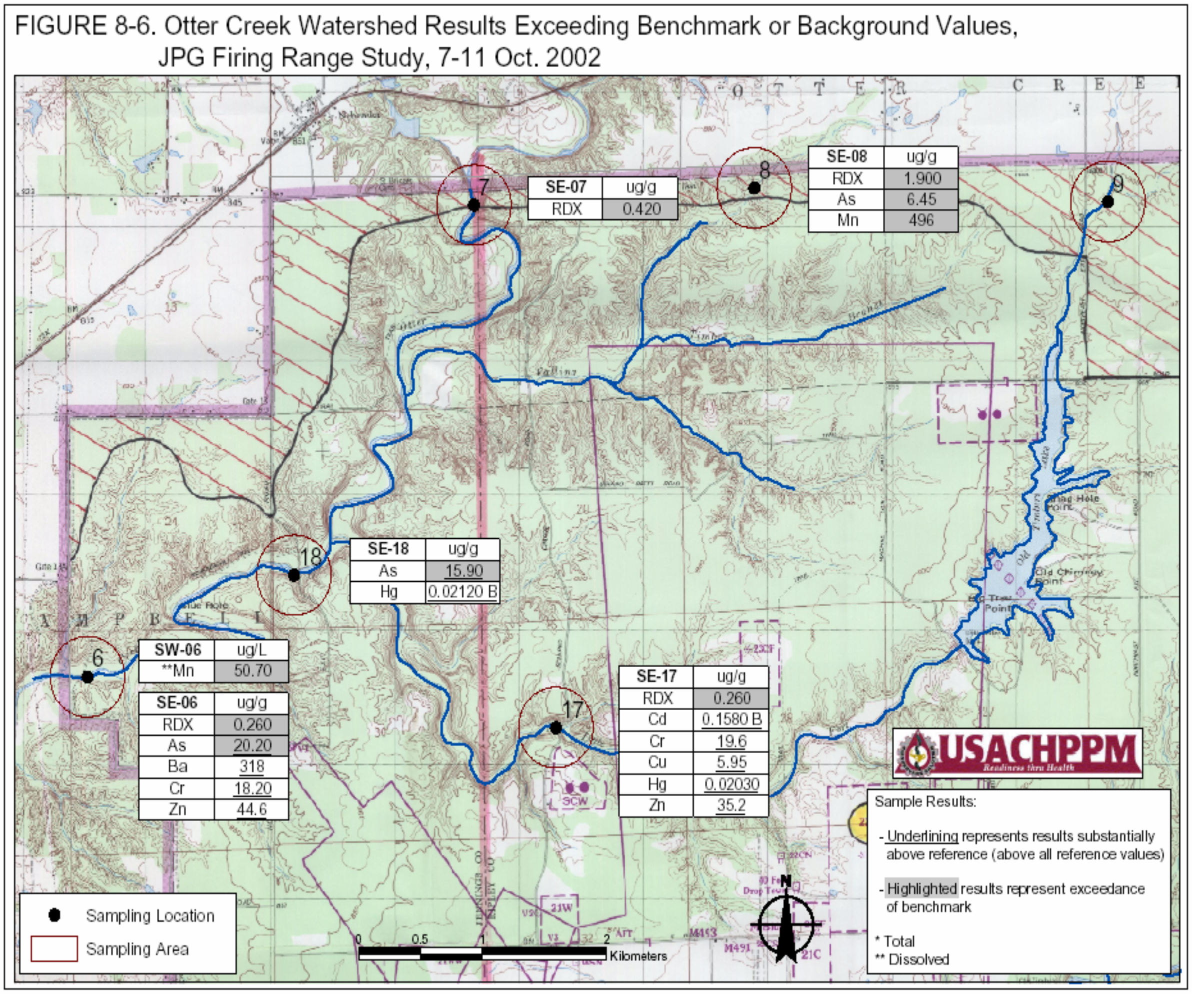


TABLE 8-22. SEEP SAMPLE RESULTS

PARAMETER	UNIT	SG-01	Reference Average (SW7-SW12)	REGULATORY CRITERIA* FEDERAL AMBIENT WATER QUALITY CRITERIA CMC	FEDERAL AMBIENT WATER QUALITY CRITERIA CCC	INDIANA AMBIENT WATER QUALITY CRITERIA CMC	INDIANA AMBIENT WATER QUALITY CRITERIA CCC
Explosives and Degradates							
HMX	µg/L	3.0 U	3.0	NA	330	No numeric criteria have been established for these compounds.	
RDX	µg/L	0.100 U	0.062	4000	190		
2,4,6-TNT	µg/L	0.030 U	0.03	570	130		
1,3-DNB	µg/L	0.090 U	0.09	110	30		
1,3,5-TNB	µg/L	0.030 U	0.03	30	14		
TETRYL	µg/L	0.50 U	0.5	NA	NA		
NB	µg/L	0.030 U	0.03	27,000			
2A-4,6-DNT	µg/L	0.10 U	0.1	NA	NA		
4A-2,6-DNT	µg/L	0.10 U	0.1	NA	NA		
2,6-DNT	µg/L	0.010 U	0.01	18,500	NA		
2,4-DNT	µg/L	0.020 U	0.02	330	230		
2-NT	µg/L	0.090 U	0.09	NA	NA		
3-NT	µg/L	0.090 U	0.09	NA	NA		
4-NT	µg/L	0.090 U	0.09	NA	NA		
Nitroglycerin	µg/L	0.090 U	0.09	1700	200		
WP	µg/L	0.026 U	0.024	0.5	0.1		
Metals							
Hardness	mg/L	**198**	160	-	-	-	-
Antimony (Total/*Dissolved*) [1]	µg/L	**0.0207 B** ***0.0143 B***	0.1036 0.0997	- 180	- 30	-	-
Arsenic	µg/L	**0.385** ***0.210***	0.983 1.027	- 340	- 150	360 -	190 -
Barium	µg/L	**46.2** ***43.7***	57.8 56.3	- 1000	1000	- -	- -
Cadmium	µg/L	**0.06020** ***0.07270***	0.04352 0.02993	- 4.3	- 2.2	4 -	1.1 -
Calcium	µg/L	**49800** ***50400***	47400 45950	- -	- -	- -	- -
Chromium	µg/L	**0.4380** ***0.1650***	0.4355 0.3898	- 570	- 74	1737 -	207 -
Copper	µg/L	**0.477** ***0.250***	1.066 1.030	- 13	- 9	18 -	9 -
Lead	µg/L	**0.42500** *0.005 U*	0.41493 0.05072	- 65	- 2.5	82 -	3 -
Magnesium	µg/L	<u>**17700**</u> <u>***17800***</u>	11502 11025	- -	- -	- -	- -
Manganese	µg/L	**51.50** ***18.80***	56.58 39.48	- 50	- -	- -	- -
Mercury	µg/L	**0.001980** ***0.000523***	0.001783 0.001508	- 1.4	- 0.77	2.4 -	0.012 -
Molybdenum	µg/L	**0.147** ***0.182***	1.055 0.997	- 16000	- 370	- -	- -
Nickel	µg/L	**2.31** ***1.90***	2.20 2.29	- 470	- 52	1418 -	158 -
Silver	µg/L	**0.0316 B** ***0.0149 B***	0.05208 0.04755	- 3.4	- -	2 -	- -
Uranium	µg/L	**1.030** ***1.010***	0.717 0.697	- 46	- 2.6	- -	- -
Vanadium	µg/L	**0.775** ***0.241***	0.809 0.663	- 280	- 20	- -	- -
Zinc	µg/L	<u>**3.500**</u> ***1.410***	1.573 1.581	- 120	- 120	117 -	106 -
Other Parameters							
Perchlorate	µg/L	1.0 U	1.0	5000	600	-	-
TOC	mg/L	**1.1**	6.1	-	-	-	-
pH (Field, Lab)	s.u.	6.85		6.5 - 9.0		-	
D.O. (Field)	mg/L	0.61		-	-	-	-
Conductivity (Field)	µohm	379		-	-	-	-
Temperature (Field)	Deg.Cel.	15.09		-	-	-	-

*-For complete citations see Table 8-3. <u>Underlining</u>-represents results substantially above reference (above all reference values). **Bold**-represents results above detection limit. **B**-represents parameter was also detected in laboratory blank for that run. **NA**-not available. **U**-under detection limit.

8.4.8.1.1 Metals and Hardness

Both total and dissolved metals samples were collected. The seep water sample had a moderate hardness value of 198 mg/L, which is about the same as the reference average for all of JPG (160 mg/L).

In general, individual total metals concentrations exceeded their dissolved metals counterparts. However, a number of metals (cadmium, calcium, magnesium, and molybdenum) had total metal concentrations below their dissolved counterparts (see Table 8-22). Most metals were detected at low levels, some at or near the corresponding metals reporting limit.

There were no metals except total and dissolved magnesium and total zinc that were substantially higher than the average reference value for the stream locations.

Overall, the metals data do not display any kind of a consistent pattern. The metals were similar to the JPG reference average concentrations for most metals (see Table 8-22). No metals exceeded reference concentrations by more than an order of magnitude.

8.4.8.1.2 Explosives and Degradates

There were no explosives detected in the seep water sample.

8.4.8.1.3 Perchlorate, TOC, and Field Parameters

Perchlorate was not detected in the seep sample. TOC, pH, dissolved oxygen, conductivity, and temperature were all in the range expected from a ground-water seep. The pH and dissolved oxygen was lower than stream samples. This would be expected but the ground water would soon equilibrate as it oxygenates and loses excess carbon dioxide.

8.4.8.1.4 Water Quality Criteria Screening

No parameters exceeded water quality criteria in the seep sample.

8.4.8.1.5 Ground-Water Seep Summary

Figure 8-2 shows the ground-water seep results exceeding benchmark or background values. The ground-water seep conclusions are based on the one sampling event data collected during the field investigation. The data collected do not account for temporal variations and represent point estimates of exposure. The seep ground-water results do not exceed Federal WQC or State WQSs and the only results that were substantially higher than the average reference values were total and dissolved magnesium and total zinc.

8.5 QUALITY ASSURANCE/QUALITY CONTROL (QA/QC)

8.5.1 Overview

Field and laboratory QA/QC procedures were followed during the JPG field investigation through strict adherence to approved procedures outlined in the QAPP. Proper sampling, handling, and shipment procedures prevented sample cross-contamination. The indicators used to assess both field and laboratory data quality include precision, accuracy, representativeness, and completeness (PARC). These parameters are discussed below.

8.5.2 Precision

Sampling precision is assessed through the evaluation of field duplicate samples. Duplicate samples are defined as samples collected simultaneously from the same source under identical conditions. Precision is stated in terms of the relative percent difference (RPD). The RPD is defined as follows:

$$\frac{(C_1 - C_2)}{\left[\frac{C_1 + C_2}{2}\right]} \times 100$$

where: C_1 = concentration of constituent in actual sample
C_2 = concentration of constituent in duplicate sample

8.5.2.1 Precision Data

Tables 8-23 and 8-24 show the calculated RPD values for the JPG surface water and sediment samples. Four pairs of field duplicates were collected for both surface water and sediment samples at Graham Creek (SW/SE-5/21 and SW/SE-16/19), Little Graham Creek (SW/SE-4/20), and Otter Creek (SW/SE-6/22) downstream sample locations. The RPD values were only calculated for constituents found above the detection limit in both duplicate/split pairs. Because HMX, RDX, and 2,4,6-TNT were found in reference samples, the detection limit was conservatively used to calculate RPD values for the explosives. When the RPD approaches 0, complete agreement is achieved between the original/duplicate pair, indicating a high degree of precision.

8.5.2.2 Surface Water RPD Results

The RPD values for surface water samples ranged from 0 to 119, with a median of 4. The majority of the duplicate metal results met the 30% RPD data quality objective specified in the QAPP. Lead, manganese, silver, and zinc concentrations were the only metals to exceed the RPD in various duplicate surface water samples.

TABLE 8-23. RPD VALUES FOR SURFACE WATER SPLIT AND DUPLICATE SAMPLE

Parameters		SW-16	SW-19	RPD (%)	SW-4	SW-20	RPD (%)	SW-5	SW-21	RPD (%)	SW-6	SW-22	RPD (%)
Explosives and Degradates													
HMX	µg/L	3.0 U	3.0 U	-	3.0 U	3.0 U	-	3.0 U	3.0 U	-	3.0 U	3.0 U	-
RDX	µg/L	0.13	0.051 J	-	0.100 U	0.100 U	-	0.039 J	0.031 J	-	0.100 U	0.021 J	-
2,4,6-TNT	µg/L	0.030 U	0.030 U	-	0.030 U	0.030 U	-	0.030 U	0.030 U	-	0.030 U	0.030 U	-
1,3-DNB	µg/L	0.090 U	0.090 U	-	0.090 U	0.090 U	-	0.090 U	0.090 U	-	0.090 U	0.090 U	-
1,3,5-TNB	µg/L	0.030 U	0.030 U	-	0.030 U	0.030 U	-	0.030 U	0.030 U	-	0.030 U	0.030 U	-
TETRYL	µg/L	0.50 U	0.50 U	-	0.50 U	0.50 U	-	0.50 U	0.50 U	-	0.50 U	0.50 U	-
NB	µg/L	0.030 U	0.030 U	-	0.030 U	0.030 U	-	0.030 U	0.030 U	-	0.030 U	0.030 U	-
2A-4,6-DNT	µg/L	0.10 U	0.10 U	-	0.10 U	0.10 U	-	0.10 U	0.10 U	-	0.10 U	0.10 U	-
4A-2,6-DNT	µg/L	0.10 U	0.10 U	-	0.10 U	0.10 U	-	0.10 U	0.10 U	-	0.10 U	0.10 U	-
2,6-DNT	µg/L	0.010 U	0.010 U	-	0.010 U	0.010 U	-	0.010 U	0.010 U	-	0.010 U	0.010 U	-
2,4-DNT	µg/L	0.020 U	0.020 U	-	0.020 U	0.020 U	-	0.020 U	0.020 U	-	0.020 U	0.020 U	-
2-NT	µg/L	0.090 U	0.090 U	-	0.090 U	0.090 U	-	0.090 U	0.090 U	-	0.090 U	0.090 U	-
3-NT	µg/L	0.090 U	0.090 U	-	0.090 U	0.090 U	-	0.090 U	0.090 U	-	0.090 U	0.090 U	-
4-NT	µg/L	0.090 U	0.090 U	-	0.090 U	0.090 U	-	0.090 U	0.090 U	-	0.090 U	0.090 U	-
Nitroglycerin	µg/L	0.090 U	0.090 U	-	0.090 U	0.090 U	-	0.090 U	0.090 U	-	0.090 U	0.090 U	-
WP	µg/L	0.024 U	0.024 U	-	0.024 U	0.024 U	-	0.024 U	0.024 U	-	0.024 U	0.024 U	-
Metals													
Hardness	mg/L	175	175	-	128	128	-	160	156	-	149	148	-
Antimony (Total/*Dissolved*)	µg/L	0.1300	0.1090	18%	0.0792	0.0947	18%	0.0964	0.0946	2%	0.0814	0.0781	4%
		0.1010	*0.1150*	13%	*0.0836*	*0.1080*	25%	*0.0993*	*0.0967*	3%	*0.0856*	*0.0793*	8%
Arsenic	µg/L	1.530	1.450	5%	0.758	0.740	2%	1.220	1.150	6%	0.914	0.900	2%
		1.360	*1.370*	1%	*0.771*	*0.713*	8%	*1.160*	*1.190*	3%	*0.989*	*1.040*	5%
Barium	µg/L	57.0	54.7	4%	44.6	44.8	0%	52.3	52.2	0%	45.0	45.9	2%
		53.4	*53.7*	1%	*44.1*	*44.1*	0%	*52.8*	*51.4*	3%	*45.0*	*44.2*	2%
Cadmium	µg/L	0.02310	0.01460	**45%**	0.00959	0.01280	29%	0.01380	0.00875	**45%**	0.01140	0.01020	11%
		0.01520	*0.01030*	**38%**	*0.00989*	*0.00671*	**38%**	*0.01220*	*0.01030*	17%	*0.00670*	*0.00709*	6%
Calcium	µg/L	50900	50500	1%	36300	37000	2%	46600	46000	1%	46400	46200	0%
		50000	*49900*	0%	*36400*	*36400*	0%	*46700*	*45800*	2%	*46300*	*45800*	1%
Chromium	µg/L	0.5750	0.4540	24%	0.0240 U	0.0322	29%	0.3110	0.3180	2%	0.3110	0.3090	1%
		0.3990	*0.3220*	21%	*0.0240 U*	*0.0240 U*	-	*0.237*	*0.2380*	0%	*0.210*	*0.2940*	**33%**
Copper	µg/L	1.270	1.100	14%	1.110	1.090	2%	1.050	1.030	2%	0.864	0.846	2%
		0.951	*0.989*	4%	*1.050*	*1.030*	2%	*0.965*	*0.935*	3%	*0.871*	*0.943*	8%
Lead	µg/L	0.37300	0.14600	**87%**	0.05550	0.03320	**50%**	0.10300	0.08630	18%	0.07200	0.05620	25%
		0.00500 U	*0.00500 U*	-	*0.00500 U*	*0.00500 U*	-	*0.01920*	*0.00936*	**69%**	*0.00935*	*0.01530*	**48%**
Magnesium	µg/L	12400	12300	1%	8910	9090	2%	10200	10200	0%	8000	7990	0%
		12200	*12100*	1%	*8910*	*9130*	2%	*10400*	*10100*	3%	*8170*	*8160*	0%
Manganese	µg/L	99.40	42.80	**80%**	31.70	29.00	9%	42.30	40.20	5%	50.60	54.00	7%
		8.48	*7.79*	8%	*23.70*	*24.90*	5%	*8.87*	*7.17*	21%	*50.70*	*22.90*	**76%**
Mercury	µg/L	0.00313	0.00234	29%	0.001970	0.00189	4%	0.002010	0.00210	4%	0.001600	0.00159	1%
		0.00163	*0.00148*	10%	*0.001830*	*0.00166*	10%	*0.001310*	*0.00138*	5%	*0.001200*	*0.00127*	6%
Molybdenum	µg/L	1.160	1.210	4%	0.479	0.498	4%	0.994	0.991	0%	0.745	0.749	1%
		1.200	*1.230*	2%	*0.502*	*0.479*	5%	*0.980*	*0.963*	2%	*0.683*	*0.714*	4%
Nickel	µg/L	2.46	2.40	2%	1.72	1.60	7%	2.04	2.04	0%	2.04	2.04	0%
		2.28	*2.26*	1%	*1.54*	*1.57*	2%	*1.98*	*1.87*	6%	*2.19*	*2.35*	7%
Silver	µg/L	0.0199 B	0.00928 B	**73%**	0.18200	0.15400	17%	0.07600	0.10500	**32%**	0.01280 B	0.01150 B	11%
		0.00816 B	*0.00957 B*	16%	*0.20900*	*0.17100*	20%	*0.09900*	*0.12700*	25%	*0.01410 B*	*0.00526 B*	**91%**
Uranium	µg/L	0.547	0.528	4%	0.312	0.320	3%	0.434	0.436	0%	0.379	0.388	2%
		0.516	*0.521*	1%	*0.319*	*0.313*	2%	*0.420*	*0.412*	2%	*0.374*	*0.371*	1%
Vanadium	µg/L	1.220	1.010	19%	0.441	0.431	2%	0.822	0.807	2%	0.629	0.625	1%
		0.801	*0.813*	1%	*0.371*	*0.370*	0%	*0.672*	*0.661*	2%	*0.526*	*0.523*	1%
Zinc	µg/L	1.590	0.941	**51%**	0.628	1.670	**91%**	0.802	0.658	20%	1.250	0.588	**72%**
		2.400	*0.605*	**119%**	*0.293*	*0.335*	13%	*0.596*	*0.517*	14%	*0.216*	*0.475*	**75%**
Other Parameters													
Perchlorate	µg/L	1.0 U	1.0 U	-	1.0 U	1.0 U	-	1.0 U	1.0 U	-	1.0 U	1.0 U	-
TOC	mg/L	9.0	9.1	1%	6.0	6.1	2%	8.2	8.2	0%	5.9	5.8	2%
pH (Field, Lab)	s.u.	8.07	8.07		7.57	7.60		7.91	7.91		8.12	8.12	
D.O. (Field)	mg/L	11.12	11.12		9.50	9.17		10.39	10.76		2.17	2.17	
Conductivity (Field)	µ ohm	400	400		231	231		355	355		262	262	
Temperature (Field)	Deg. Cel.	13.36	13.36		13.66	13.66		13.75	13.69		16.90	16.90	

Bold-represents RPD values that exceeded the 30% allowed **B**-represents parameter was also detected in laboratory blank for that run. **J**-estimate value below reporting limit. **U**-under detection limit.

TABLE 8-24. RPD VALUES FOR SEDIMENT SPLIT AND DUPLICATE SAMPLE

PARAMETER	UNIT	SE-16	SE-19	RPD (%)	SE-4	SE-20	RPD (%)	SE-5	SE-21	RPD (%)	SE-6	SE-22	RPD (%)
Explosives and Degradates													
HMX	µg/g	**0.320**	0.050 U	146%	0.050 U	0.050 U	0%	0.050 U	0.050 U	-	**0.080**	**0.046 J**	54%
RDX	µg/g	**1.100**	0.010 U	196%	**0.190**	**0.140**	30%	**0.120**	0.010 U	119%	**0.260**	**0.250**	4%
2,4,6-TNT	µg/g	**0.130**	**0.018**	**151%**	**0.040**	**0.030**	29%	**0.020**	**0.007 J**	52%	**0.046**	**0.040**	14%
1,3-DNB	µg/g	0.020 U	0.020 U	-	0.020 U	0.020 U	-	0.020 U	0.020 U	-	0.020 U	0.020 U	-
1,3,5-TNB	µg/g	0.020 U	0.020 U	-	0.020 U	0.020 U	-	0.020 U	0.020 U	-	0.020 U	0.020 U	-
TETRYL	µg/g	0.020 U	0.020 U	-	0.020 U	0.020 U	-	0.020 U	0.020 U	-	0.020 U	0.020 U	-
NB	µg/g	0.020 U	0.020 U	-	0.020 U	0.020 U	-	0.020 U	0.020 U	-	0.020 U	0.020 U	-
2A-4,6-DNT	µg/g	0.020 U	0.020 U	-	0.020 U	0.020 U	-	0.020 U	0.020 U	-	0.020 U	0.020 U	-
4A-2,6-DNT	µg/g	0.050 U	0.050 U	-	0.050 U	0.050 U	-	0.050 U	0.050 U	-	0.050 U	0.050 U	-
2,6-DNT	µg/g	0.010 U	0.010 U	-	0.010 U	0.010 U	-	0.010 U	0.010 U	-	0.010 U	0.010 U	-
2,4-DNT	µg/g	0.020 U	0.020 U	-	0.020 U	0.020 U	-	0.020 U	0.020 U	-	0.020 U	0.020 U	-
2-NT	µg/g	0.020 U	0.020 U	-	0.020 U	0.020 U	-	0.020 U	0.020 U	-	0.020 U	0.020 U	-
3-NT	µg/g	0.020 U	0.020 U	-	0.020 U	0.020 U	-	0.020 U	0.020 U	-	0.020 U	0.020 U	-
4-NT	µg/g	0.060 U	0.050 U	-	0.070 U	0.070 U	-	0.050 U	0.020 U	-	0.080 U	0.070 U	-
Nitroglycerin	µg/g	0.050 U	0.050 U	-	0.050 U	0.050 U	-	0.050 U	0.050 U	-	0.050 U	0.050 U	-
WP	µg/g	0.0010 U	0.0010 U	-	0.0010 U	0.0010 U	-	0.0010 U	0.0010 U	-	0.0010 U	0.0010 U	-
Moisture (WP only)	Percent	20	20	0%	20	20	0%	15	17	13%	19	18	5%
Metals													
Antimony	µg/g	**0.151**	**0.162**	7%	**0.365**	**0.259**	34%	**0.186**	**0.172**	8%	**0.253**	**0.343**	30%
Arsenic	µg/g	**4.84 B**	**4.26 B**	13%	**8.02**	**9.28**	15%	**4.71 B**	**6.96**	39%	**20.20**	**18.70**	8%
Barium	µg/g	**229**	**230**	0%	**183**	**196**	7%	**212**	**210**	1%	**318**	**287**	10%
Cadmium	µg/g	**0.1060 B**	**0.1010B**	5%	**0.1330 B**	**0.0945 B**	34%	**0.0669 B**	0.0587 U	-	0.0587 U	0.0587 U	-
Chromium	µg/g	**11.5**	**18.5**	47%	**19.40**	**13.4**	37%	**11.40**	**12.6**	10%	**18.20**	**33.6**	**59%**
Copper	µg/g	**3.86**	**3.43**	12%	**3.63**	**3.79**	4%	**2.37**	**3.14**	28%	**3.59**	**3.59**	0%
Lead	µg/g	**7.36**	**7.64**	4%	**7.76**	**7.59**	2%	**6.03**	**8.52**	34%	**10.50**	**10.20**	3%
Manganese	µg/g	**310**	**225**	32%	**391**	**325**	18%	**183**	**230**	23%	**326**	**298**	9%
Mercury	µg/g	**0.0080 J**	**0.01030**	-	**0.01740**	**0.01360**	25%	**0.01450**	**0.00840 J**	**-**	**0.00710 B,J**	**0.01160 B**	-
Molybdenum	µg/g	**0.329**	**0.438**	28%	**1.150**	**0.802**	36%	**0.516**	**0.476**	8%	**0.868**	**0.897**	3%
Nickel	µg/g	**3.04**	**3.32**	9%	**8.27**	**4.42**	**61%**	**3.34**	**3.38**	1%	**5.73**	**5.72**	0%
Silver	µg/g	**0.0545**	**0.0846**	43%	**0.1100**	**0.0606**	**58%**	**0.0593**	**0.0899**	41%	**0.0803**	**0.0625**	25%
Uranium	µg/g	**0.646**	**0.618**	4%	**0.516**	**0.504**	2%	**0.286**	**0.338**	17%	**0.719**	**0.755**	5%
Vanadium	µg/g	**17.5**	**15.1**	15%	**35.4**	**20.8**	**52%**	**15.8**	**17.7**	11%	**25.8**	**26.4**	2%
Zinc	µg/g	**22.8**	**20.1**	13%	**24.3**	**23.4**	4%	**18.6**	**19.7**	6%	**44.6**	**42.5**	5%
Moisture	Percent	21.9	18.3	18%	18.7	18.4	2%	18.2	17.9	2%	20.1	20.7	3%
Other Parameters													
Total Organic Matter	Percent	0.8	0.5	46%	0.8	0.9	12%	0.5	0.5	0%	0.9	0.9	0%
Perchlorate	µg/g	0.013 U	0.013 U	-	0.012 U	0.012 U	-	0.013 U	0.013 U	-	0.013 U	0.012 U	-

Bold-represents RPD values that exceeded the 50% allowed **B**-represents parameter was also detected in laboratory blank for that run. **J**-estimate value below reporting limit. **U**-under detection limit.

8.5.2.3 Sediment RPD Results

The RPD values for sediment samples ranged from 0 to 196, with a median of 18. The majority of the duplicate sediment metal results met the 50% RPD data quality objective specified in the QAPP. The explosives, HMX, RDX, and 2,4,6-TNT exceeded the RPD data quality objective for various duplicate sediment samples. According to accepted EPA methods, the explosives values at the locations where duplicated samples exceed criteria would be estimated values (USEPA 1991). Chromium, nickel, silver, and vanadium were the only metals in some samples where the RPD values were in excess of 50. Overall, the sediment metal results were slightly more variable than the surface water metal results.

8.5.2.4 Precision Summary

Overall, the project precision for environmental analysis has been professionally judged to be adequate for an ecological health screening.

8.5.3 Accuracy

8.5.3.1 Field Accuracy

The field sampling accuracy was qualitatively assessed through the evaluation of equipment and container blanks to determine if contaminants were introduced during the sampling event. The criterion for evaluating blank contamination dictates that no contamination should be found in the blank. The field blank samples are described below:

- Field Equipment Blank. Two field equipment blanks were collected while onsite at JPG by flushing laboratory grade reagent water through the sampling equipment. The collection procedures used for the equipment blank mirrored the field sample collection procedures. For metals analyses, both unfiltered and filtered samples were collected. The filtered sample water was run through a 0.45-micron filter prior to collection into the sample bottle. The equipment blanks were analyzed for explosives, TOC, perchlorate, and metals (total and dissolved).
- Container Blank. Two container blanks were collected at JPG by pouring laboratory grade reagent water into the sample containers. The container blanks were analyzed for explosives, TOC, perchlorate, and metals (total and dissolved).
- Sediment Equipment Blank. Two sediment equipment blanks were collected by collecting the rinse water from the stainless steel bowl and plastic scoop used to homogenize sediment samples prior to transference into the sample bottles. These samples were used as an indicator that contamination was introduced through the stainless steel bowl.

8.5.3.1.1 Field Blank Results

The results of the rinse blank samples are shown in Table 8-25. The blank sample results, along with matrix spike duplicate (MSD) percent recoveries, are discussed below.

TABLE 8-25. BLANK RESULTS

Parameters	Units	Container Blank 1	Container Blank 2	Equipment Blank 1	Equipment Blank 2	Sediment Equipment Blank 1	Sediment Equipment Blank 2
Explosives and Degradates							
HMX	µg/L	3.0 U	3.0 U	3.0 U	3.0 U	3.0 U	3.0 U
RDX	µg/L	0.100 U	0.100 U	**0.019 J**	0.100 U	0.100 U	0.100 U
2,4,6-TNT	µg/L	0.030 U	0.030 U	0.030 U	0.030 U	0.030 U	0.030 U
1,3-DNB	µg/L	0.090 U	0.090 U	0.090 U	0.090 U	0.090 U	0.090 U
1,3,5-TNB	µg/L	0.030 U	0.030 U	0.030 U	0.030 U	0.030 U	0.030 U
TETRYL	µg/L	0.50 U	0.50 U	0.50 U	0.50 U	0.50 U	0.50 U
NB	µg/L	0.030 U	0.030 U	0.030 U	0.030 U	0.030 U	0.030 U
2A-4,6-DNT	µg/L	0.10 U	0.10 U	0.10 U	0.10 U	0.10 U	0.10 U
4A-2,6-DNT	µg/L	0.10 U	0.10 U	0.10 U	0.10 U	0.10 U	0.10 U
2,6-DNT	µg/L	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U
2,4-DNT	µg/L	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U
2-NT	µg/L	0.090 U	0.090 U	0.090 U	0.090 U	0.090 U	0.090 U
3-NT	µg/L	0.090 U	0.090 U	0.090 U	0.090 U	0.090 U	0.090 U
4-NT	µg/L	0.090 U	0.090 U	0.090 U	0.090 U	0.090 U	0.090 U
Nitroglycerin	µg/L	0.090 U	0.090 U	0.090 U	0.090 U	0.090 U	0.090 U
WP	µg/L	0.024 U	0.024 U	0.024 U	0.024 U	0.024 U	0.024 U
Metals							
Antimony (Total/*Dissolved*)	µg/L	0.00400 U *NA*	0.01360 B *NA*	**0.00884 B** *0.004 U*	**0.00430 B** *0.004 U*	**0.0787** *NA*	NA *NA*
Arsenic	µg/L	**0.0234 B** *NA*	**0.0193 B** *NA*	**0.0175 B** ***0.0231 B***	**0.0157 B** ***0.0128 B***	**0.0182** *NA*	NA *NA*
Barium	µg/L	**0.00837** *NA*	**0.00680** *NA*	**0.01230** ***0.03560***	**0.00481** *0.00400 U*	**0.03260** *NA*	NA *NA*
Cadmium	µg/L	0.00600 U *NA*	0.00600 U *NA*	0.00600 U ***0.0079***	0.00600 U *0.00600 U*	0.00600 U *NA*	NA *NA*
Calcium	µg/L	**35.10** *NA*	**30.70** *NA*	**39.40** **10.70**	**35.10** ***7.73***	**43.70** *NA*	NA *NA*
Chromium	µg/L	0.3080 *NA*	0.0240 U *NA*	0.0240 U *0.0240 U*	**0.0343** *0.0240 U*	0.0240 U *NA*	NA *NA*
Copper	µg/L	0.023 U *NA*	0.023 U *NA*	0.023 U *0.023 U*	0.023 U *0.023 U*	0.120 *NA*	NA *NA*
Lead	µg/L	0.00500 U *NA*	0.00500 U *NA*	0.00500 U *0.00500 U*	0.00500 U *0.00500 U*	0.04590 *NA*	NA *NA*
Magnesium	µg/L	**39.20 B** *NA*	**39.70 B** *NA*	**36.70 B** ***12.30 B***	**40.90 B** *6.67 U*	**41.50 B** *NA*	NA *NA*
Manganese	µg/L	**0.0266** *NA*	0.0110 U *NA*	**0.0134** *0.0110 U*	0.0010 U *0.0110 U*	0.0129 *NA*	NA *NA*
Mercury	µg/L	**0.000336** *NA*	**0.003760** *NA*	**0.003620** ***0.003280***	**0.005150** ***0.000395***	**0.004040** *NA*	NA *NA*
Molybdenum	µg/L	**0.00663 B** *NA*	**0.03050 B** *NA*	**0.01230 B** ***0.01340 B***	**0.00626 B** ***0.00817 B***	**0.00762 B** *NA*	NA *NA*
Nickel	µg/L	**0.0906** *NA*	**0.0806** *NA*	**0.0289** *0.0110 U*	0.0110 U *0.0110 U*	**0.0318** *NA*	NA *NA*
Silver	µg/L	**0.0131 B** *NA*	**0.0255 B** *NA*	**0.0172 B** ***0.0149 B***	**0.0115 B** ***0.0120 B***	**0.0135 B** *NA*	NA *NA*
Uranium	µg/L	0.010 U *NA*	0.010 U *NA*	0.010 U *0.010 U*	0.010 U *0.010 U*	0.010 U *NA*	NA *NA*
Vanadium	µg/L	0.018 U *NA*	0.018 U *NA*	0.018 U *0.018 U*	0.018 U *0.018 U*	0.018 U *NA*	NA *NA*
Zinc	µg/L	0.062 U *NA*	**0.621** *NA*	**0.130** *0.062 U*	**0.751** *0.062 U*	**1.100** *NA*	NA *NA*
Other Parameters							
Perchlorate	µg/L	1.0 U	1.0 U	-	1.0 U	NA	NA
TOC	mg/L	0.5 U	0.5 U	0.5 U	0.5 U	NA	NA

Bold-represents results above detection limit. **B**-represents parameter was also detected in laboratory blank for that run. **NA**-not analyzed. **U**-under detection limit.
J-estimated value below reported limit.

8.5.3.1.2 Explosives

No explosives or degradates were detected above the instrument detection limit in any of the field blank samples. An estimated value for RDX (0.019 μg/L), below the reporting limit of 0.100 μg/L was identified in Equipment Blank 1.

8.5.3.1.3 Metals

No significant metal contamination was found in the blank samples. Metals levels were not found above 10% of the detection limit except for molybdenum in the SW-16 sample (0.32 μg/L) and zinc in all the blank samples. The low zinc levels may be explained as inherent in water chemistry and not due to sample contamination.

8.5.3.1.4 Perchlorate

Perchlorate was not detected in any of the blank samples above the detection limit of 1.0 μg/L.

8.5.3.2 Laboratory Accuracy

Laboratory accuracy is the closeness of agreement between an observed result and the true value of a sample analysis. Accuracy is expressed in terms of bias (high or low) and is assessed through the use of QC matrix spike and MSD samples. The percent accuracy (R) may be estimated by:

%*R* = (*Obs/Theor*)x 100

where: Obs = the measured value
Theor = the value of the spike added

8.5.3.2.1 Explosives

- Surface Water. Per USACHPPM DLS Report No. 02E1030-1, water matrix spikes were acceptable for all explosive analytes.
- Sediment. Per USACHPPM DLS Report No. 02E1119-1, soil matrix spikes were acceptable for all explosive analytes.

8.5.3.2.2 Metals

- Surface Water. The percent recovery for matrix spikes ranged from 60-1960%. The QAPP specified an accuracy data quality objective of 80-120%. All metals fell within the QA specifications except calcium, magnesium, and zinc. Two of the four matrix spikes/spike duplicates for calcium and magnesium were affected by native sample concentrations overwhelming spike concentrations. The remaining two matrix spikes/spike duplicates for those analytes were within QA specifications. One matrix spike/spike duplicate for zinc was just above the QA specifications at 124% and 125%, respectively. Laboratory replicate analyses for all metals, except calcium had RPD ranges from 0 to 10%, and were within precision limits of +/- 25%. There were two matrix spikes/spike duplicates for calcium with RPDs of 32% and 143%. Both samples were affected by high native sample concentrations. Based on all of the laboratory QC values, the surface water metals data are considered reliable.

- Sediment. The percent recovery for sediment matrix spikes ranged from 66-337%. The QAPP specified an accuracy data quality objective of 70-130%. All metals sediment results fell within the QA specifications except magnesium and chromium. One matrix spike duplicate for manganese recovered 66% of the spiked concentration, just below the QA specifications, and one matrix spike sample for chromium recovered 337% of the spiked concentration. Laboratory replicate analyses for sediment metals, except for one chromium (91%) and one manganese (43%) matrix spike/spike duplicate, had RPD ranges from 0 to 15%, and were within precision limits of +/- 30%. Based on all of the laboratory QC values, the sediment metals data are considered reliable.
- Perchlorate. Laboratory water matrix spike percent recoveries for perchlorate ranged from 104-114% and were within the acceptance limits of 80-120% specified in the QAPP. Likewise, laboratory sediment matrix spike percent recoveries for perchlorate ranged from 90.1-127% and were within the acceptance limits of 70-130% specified in the QAPP. Therefore, the surface water and sediment samples are considered acceptable for perchlorate.

8.5.4 Representativeness

Representativeness is defined as the degree to which the data accurately and precisely represent a characteristic of a population, parameter variations at a sample site, or an environmental condition. Representativeness is a qualitative parameter concerned most with the proper design of the sampling program.

The surface water and sediment sampling approach was a combination of purposive/judgmental sampling and a variation of the search sampling typically used in locating suspected "hot spots." Surface water and sediment data obtained from this sampling approach typically have the following limitations: (1) concentrations may not represent the average surface water or sediment concentrations at a sampling site; (2) the distribution of concentrations may not accurately represent the concentration distribution over JPG range areas; and (3) the concentration distribution is based on a predetermined conceptual model or understanding of constituent distributions. Therefore, the surface water and sediment sampling design and collection method provides reasonable yet conservative exposure concentrations for the surface water and sediment criteria screening assessment.

Representativeness was assessed by reviewing sample collection methods, equipment, and sample containers used during the field investigation, in addition to evaluating the RPD values calculated from the duplicate samples. Based on the evaluation of the factors above, the samples collected during the JPG field investigation are considered to be representative of the environmental conditions in the selected areas of the firing ranges and the impact area at JPG.

8.5.5 Completeness

Completeness is defined by the USEPA as a measure of the amount of valid data obtained from a sampling system and/or laboratory measurement system compared to the amount of data that was expected to be obtained under normal conditions. Data quality objectives were set at 90% for field and laboratory completeness. All surface water samples (100%) identified in the QAPP were collected during the field investigation. There was three seep (spring) water samples identified in the QAPP and only one sample could be collected (30%) due to the drought (springs were not flowing). All sediment samples (100%) identified in the QAPP were collected during the field investigation.

8.5.6 QA/QC Summary

The analytical results from the surface water and sediment samples are considered to be reliable and accurate according to field and laboratory QA/QC procedures. The majority of the samples were within acceptable limits for laboratory control sample spike recoveries. All data generated are considered reliable, and they can be used in the ecological screening.

Due to the volume of paper involved, the raw analytical data have not been reproduced in this report. The raw data will be kept on file at USACHPPM and can be provided upon request.

8.6 SUMMARY

8.6.1 Collective Upstream Reference Sampling Locations

Since there was no upstream reference location for two of the watersheds (Middle Fork Creek and Marble Creek), the results from the six reference locations in the other watersheds were averaged to develop a reference for the metals. This reference value was used to determine if munitions compounds and firing range activities may have impacted surface water quality. Three explosives constituents (HMX, RDX, 2,4,6-TNT) were detected in the reference sediment samples at higher concentrations then downstream locations.

8.6.2 Middle Fork Creek Sampling Locations

Based on the surface water, sediment and biological data collected from Middle Fork Creek, the munitions constituents and firing range activities in the Middle Fork Creek drainage basin did not appear to adversely affect the basin's surface water quality or benthic ecology. There was an increase in several surface water total metals concentrations at sampling location 13 (midstream), but were back to reference values by sampling location 01 (downstream). There were several increases in sediment metals concentrations over reference values at both sampling locations.

8.6.3 Big Creek Sampling Locations

Based on the surface water, sediment and biological data collected from Big Creek, the munitions constituents and firing range activities in the Big Creek drainage basin did not appear to adversely affect the basin's surface water quality or benthic ecology. There was an increase in total lead, manganese, and zinc at downstream sampling location and an increase in surface water total and dissolved uranium at both midstream and downstream sampling locations. At the midstream sampling location there was an increase in metals sediment concentrations over reference values but all returned to background values by the time Big Creek exited the installation.

8.6.4 Marble Creek Sampling Location

Based on the surface water, sediment and biological data collected from Marble Creek, the munitions constituents and firing range activities in the Marble Creek drainage basin did not appear to adversely affect the basin's surface water quality or benthic ecology. Marble Creek surface water and sediment results were almost entirely below reference values.

8.6.5 Little Graham Creek Sampling Locations

Based on the surface water, sediment and biological data collected from Little Graham Creek, the munitions constituents and firing range activities in the Little Graham Creek drainage basin did not appear to adversely affect the basin's surface water quality or benthic ecology. Most of the surface water metals results were below reference values. The sediment metals results indicated that the majority of the metals increased over the watershed reference values but only 4 of the 12 were higher than the average reference values at the furthest downstream sampling location.

8.6.6 Graham Creek Sampling Locations

Based on the surface water, sediment and biological data collected from Graham Creek, the munitions constituents and firing range activities in the Graham Creek drainage basin did not appear to adversely affect the basin's surface water quality or benthic ecology. The surface water results indicated an increase in a few of the metals at the midstream sampling location (16) but none were substantial when considering variability between duplicate and split samples and reference locations. There were no substantial increases in sediment metals concentrations compared to reference values.

8.6.7 Otter Creek Watershed Sampling Locations

Based on the surface water, sediment and biological data collected from Otter Creek, the munitions compounds and firing range activities in the Otter Creek drainage basin did not appear to adversely affect the basin's surface water quality or benthic ecology. None of the surface water metals increased substantially in downstream locations compared to reference locations. Most of the metals sediment concentrations increased in midstream locations compared to reference values. However, only arsenic, barium, chromium, and zinc remained substantially higher at the furthest downstream location (06).

8.7 CONCLUSIONS

There were no exceedances of Federal WQC or State WQSs in the surface water. There were a few SQBs exceeded in the sediment results to include reference locations. HMX, RDX, and 2,4,6-TNT were detected at very low levels in the sediment samples to include the reference locations. The general conclusion was that the aquatic benthic macroinvertebrate community was not adversely impacted by any of the munitions related constituents.

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